II. INTERNATIONAL EDİRNE RED SYMPOSIUM

“Natural Colorants from Plants”

October 2-5, 2023
Edirne - TÜRKİYE

EDITORS

Prof. Dr. Mustafa TAN

Dr. Tolga ERDOĞAN

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Prof. Dr. Erhan TABAKOĞLU
(Rector of Trakya University, Edirne-Türkiye)

Edirne, the meeting point of different cultures and civilizations, has a rich history and unique cultural values. These lands have hosted different cultures for thousands of years, from the Thracians to the Roman, Byzantine and Ottoman Empires. Each civilization has left cultural or architectural traces on this city. Unfortunately, some of these values have been lost or lost their importance over time. The magnificent Edirne Red, which fascinated Europe in the 17th and 18th centuries, has become one of our cultural values forgotten over time. This magnificent color, obtained through long and laborious processes with the dye obtained from the roots of the madder (*Rubia tinctorum* L.) plant, is being tried to be brought back into the city culture with the intense work of Trakya University. Our university's studies on Edirne Red have intensified especially after 2017. With the projects, publications, books, exhibitions, interviews, panels, field days and symposiums produced in the last six years, public awareness has been created and some commercial activities have been initiated.

Our university's "*1. International Edirne Red e-Symposium*" is the first major scientific meeting on this subject. The more comprehensive meeting of this meeting, "*2. International Edirne Red Symposium*" was held in Edirne on 2-5 October 2023. At the symposium, whose main theme was *Natural Colorants from Plants*, 46 papers were presented by 62 participants from 7 different countries. Researchers from Greece, Bulgaria, Romania, Serbia, the Netherlands and Iran, mostly from Turkey, attended the symposium. During the symposium, in addition to scientific presentations, events such as exhibitions, a madder harvest activity and a trip to the Silk Museum in Soufli, Greece, were also held.

The 2nd International Edirne Red Symposium has made great contributions to Edirne Red studies. Edirne Red has been discussed with different aspects such as history, economy, literature, textile, agriculture, food and tourism. Researchers from different institutions came together and new areas of study were determined. This symposium has been completed as an important stage for the activities to be carried out from now on. The final work of the symposium is the 2nd International Edirne Red Proceedings Book, which brings together the presented papers.

I would like to thank the scientists who made valuable contributions to our symposium and book, which we realized based on the fact that national development is possible by carrying local values to today's world. I would like to thank Prof. Dr. Mustafa Tan, Assoc. Prof. Dr. Nilgün Becenen, Assoc. Prof. Dr. Gülşah Gedik, Assoc. Prof. Dr. Adnan Tülek, Asst. Prof. Dr. İsmail Yüce, Lec. Burak İşçimen, Lec. Orkun Akman, Lec. Necla Sevinir Bakla, Agric. Eng. M.Sc. Merve Güzel, Nadir Kartal, Lec. Dr. Tolga Erdoğan, Res. Asst. Dr. Gökben Şahin and Res. Asst. Hakan Nazlı, who were on the organizing committee, and everyone who contributed. I hope it will be a resource that will inspire researchers.

Greetings and respects…

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ANALYSIS OF ORGANIC COLOURANTS FROM PLANTS USING LIQUID CHROMATOGRAPHY CASE STUDY: MADDER

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Among the various natural organic colourants used in the painting art and dyeing industry of the past, madder is probably the most important, as it has been used uninterruptedly since antiquity in almost any part of the world. Several madder species which belong to the *Rubiaceae* family can be found in various regions of the globe. In the European continent and the Mediterranean area, the following madder species are found (Cardon, 2007): *Rubia tinctorum (*madder), *Rubia peregrina* (wild madder), *Galium* species (bedstraws) with the main representative being *Galium verum* (lady's bedstraw) and *Asperula* species (woodruffs) with the main representative being *Asperula tinctoria* (dyer's woodruff).

A variety of different spectroscopic and chromatographic methods have been suggested in the open literature to identify madder in microsamples which are extracted from cultural heritage objects, including paintings and textiles. Liquid Chromatography (LC) coupled to a Photo-Diode-Array (PDA) detector and mass spectrometry (MS) is the most commonly used, as it combines three major advantages. In particular, LC-PDA-MS is a separation technique, has very low limits-of-detection (LODs) and provides easily semi-quantitative results. These advantages are briefly discussed next.

Separation is important for effective analysis and identification of natural organic colourants, as these are mixtures that contain different compounds. For example, compounds which are often detected in madder extracts are shown Figure 1. In a typical LC system, prior to the identification step which is achieved by the detectors (PDA, MS), the components of the mixture are carried by a mobile liquid phase and are directed to the chromatographic column. Intermolecular interactions are developed between the mixture components and the stationary phase of the column, resulting in different retention times for the different mixture components. Consequently, separation is achieved.

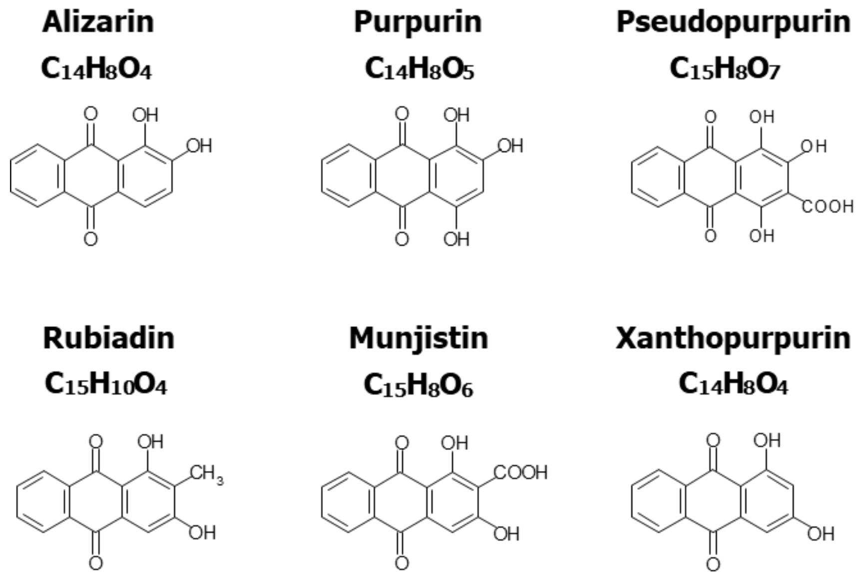

Figure 1. Examples of madder components

LC methods are accompanied by low LODs. For example, in a LC-PDA method which was developed for the determination of anthraquinones, the LODs for alizarin and purpurin were for both compounds 0.04 μg mL^{-1} (Vasileiadou et al., 2021). Low LODs imply that the quantity of sample which is required to perform a successful analysis is very small. This is an extremely important advantage of LC, as it suggests that only tiny samples, which are sometimes unintentionally "produced" during a conservation and/or cleaning process, should be removed from the original object.

Semi-quantitative results, which are usually reported as relative LC peak areas, are extremely useful to identify the exact biological source (i.e. madder species) that was used for the preparation of a madder lake or dye, used in an object of the cultural heritage (Wouters 2001; Wouters et al., 2008). Moreover, these semi-quantitative results are very useful to study degradation processes of madder which are developed because of ageing (Clementi et al., 2007; Manhita et al., 2011; Degani et al., 2017; Vasileiadou et al., 2021, 2022).

The identification of madder in objects of the cultural heritage is discussed in numerous reports which are found in the open literature. For the purposes of this presentation, six case studies (Table 1) were discussed stressing the advantages of LC for the analysis and identification of madder. These previously published case studies described the identification of madder in objects of the Mediterranean cultural heritage. The objects (paintings, fabrics and textiles) correspond to a vast period, ranging from the 11th century BC to the 18th century AC.

Table 1. Examples of case studies which describe the identification of madder in objects of the Mediterranean cultural heritage. The corresponding key-references are included

Objects	**Reference**
Pharaonic mummies	Tamburini and Dyer, 2019
Hellenistic and Roman funeral figurines	Fostiridou et al., 2016
Coptic textiles - Roman and Byzantine period	Karapanagiotis et al., 2019
Postbyzantine icons from the Cretan School of Iconography	Valianou et al., 2011
Ecclesiastical textiles from Mount Athos	Karapanagiotis and Karadag, 2015
Ottoman textiles from the area of Thessaloniki, Greece	Vivdenko et al., 2017

Finally, a possible connection of madder with the Shroud of Turin was briefly mentioned. Samples extracted from the object were dated in 1989 with the C-14 method. The conclusion was that the object is of Medieval origin (Damon et al., 1989). Several years later, R.N. Rogers performed microchemical tests on remaining parts of the removed samples. According to the published report (Rogers 2005), the results of the tests showed that madder was present in the tested samples. Rogers suggested that the dated sample belongs to later intervention (addition) and it does not correspond to the alleged original object. According to Rogers, madder was used to dye the later addition to make it look similar to the original object.

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NEW PROJECTS FOR TEXTILE PRODUCTION IN SILK ROAD MUSEUMS

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ABSTRACT

The Silk Road, spanning from one end of the world to the other, has served as a central route for commercial interaction between the East and the West, connecting diverse regions through trade, knowledge, culture, art, and commerce. Throughout history, structures built as trade routes, such as the Silk Road, have been repurposed in Silk Road regions through projects, transforming unused buildings into museums. These Silk Road museums have evolved into places where cultural heritage is revitalized, actively participating in intercultural dialogue initiatives.

This study focuses on the significance of the Silk Road and highlights major projects aimed at its redevelopment. It discusses the revitalization of textile production in Silk Road museums, presenting examples of conferences, workshops, exhibitions, and collaborative projects within the scope of these initiatives. The establishment of an International Silk Museums Network is proposed to facilitate long-term projects involving experts, fostering collaborative efforts.

In 2018, the International Silk Museums Conference was organized in Valencia. Directors of silk museums from Spain, Italy, France, Georgia, Kazakhstan, Sweden, and Turkey, recognized by UNESCO as the European Silk City, collaborated on joint projects in their respective regions. These projects emphasized the entrepreneurial revival of past textile materials as part of efforts to rejuvenate Silk Road studies.

Silk Road museums host a variety of materials related to silk and the Silk Road. Despite influencing various countries through which the historic Silk Road passed, museums dedicated to this subject have unfortunately remained limited. Since 2000,

numerous Silk Road museums have been established in locations traversed by this historical route. This study explores Turkey's Trabzon Silk Road Museum and Bursa Silk Museum, along with international examples such as the Valencia Silk Museum in Spain, Como Silk Education Museum in Italy, China National Silk Museum, and Soufi Silk Museum. It examines displayed textile materials and projects aimed at reviving their reproduction. Within these projects, the trail of "Edirne Kırmızısı" (Edirne red) will be traced.
Keywords: Silk Road, Silk Road Projects, Cultural Heritage, Edirne Kırmızısı, Edirne Red

INTRODUCTION

The Silk Road, spanning from historical times to the present, constitutes the physical pathways through which inter-country trade relations have been constructed, connecting diverse geographies. Serving as a conduit for commercial interaction between the East and the West, it has become a center for knowledge, culture, art, and commerce in our country. Throughout history, cities that served as trade routes have repurposed unused buildings through Silk Road projects, transforming them into museums. In these spaces where cultural heritage is revitalized, initiatives for intercultural dialogue have also commenced.

In the contemporary context, the revival efforts of the Silk Road, driven by its historical significance, have evolved into collaborative projects involving local governments, museums, and universities. Within the scope of these projects, support is provided to artists through the revitalization of textile products in Silk Road museums and the redesigning of traditional items with modern designs. The distribution of weaving looms to the public for the revitalization of traditional production supports the sustainability of production models.

Silk Road studies have maintained their prominence through continuous conferences, symposiums, and exhibitions since 2010, transforming into collaborative projects. An International Silk Museums Network has been established with the participation of experts. An international conference on "Cultural and Architectural Interactions of Countries along the Silk Road," organized by the International

Association of Silkroad Universities, took place in Nishinomiya city, hosted by Mukogawa University in Japan, from July 14 to 16, 2012 (Bau Haber, 2011).

In 2007, a group of volunteer entrepreneurs established the "Silk Road Global Union" as an international non-governmental organization (NGO) with the aim of reviving the Silk Road tradition. This initiative brought together different structures, countries, commercial entities, civil society organizations, and participants from around the world. The organization was founded to create a platform where cities could come together to develop and shape their visions, tourism, and economic-social development projects in accordance with both ancient and modern traditions. The goal was to foster collaboration among diverse stakeholders to promote the revitalization of the Silk Road heritage on a global scale (Gaziantep Belediyesi, 2012).

From November 9 to 11, 2012, the "7th Silk Road Mayors Forum" took place at the Zeugma Museum Culture and Congress Center, the world's largest museum, located in Gaziantep, Turkey. The conference aimed to revive historical cities along the Silk Road, and representatives from various countries, including China, Kazakhstan, Uzbekistan, Turkmenistan, Kyrgyzstan, and Azerbaijan, joined Turkish delegates. The mayors of cities along this route convened to discuss strategies for revitalizing historical cities.

Hosted by the Gaziantep Metropolitan Municipality, the annual forum provided a platform for municipal leaders to exchange ideas and collaborate on initiatives related to the Silk Road. The 6th edition of the forum was held in Grozny, Chechnya, in 2011, and Gaziantep was selected as the venue for the following year's gathering (Gaziantep Belediyesi, 2012).

On March 14, 2013, hosted by the Bursa Metropolitan Municipality in collaboration with the Ministry of Culture and Tourism and the UNESCO International Institute for Central Asian Studies, I participated in the 'Silk Road Symposium.' The event aimed to highlight the economic, cultural, and historical significance of the thousands of kilometers-long road stretching from the Far East to the West. The symposium brought attention to the Silk Road as a connection that amalgamated religions, races, and cultures over 2000 years, and discussed projects for the revival of the Historical Silk Road.

Bursa, situated at the intersection of the Silk and Spice Roads, was emphasized as a crucial location that blends cultures, underscoring the importance of Silk Road projects. Projects were presented that focused on preserving and revitalizing historical structures constructed along this route that are no longer in use. The initiatives aimed to restore and preserve historical buildings, ranging from the 700-year-old Ottoman civilization along the Silk Road to the traces of the 2300-year-old Bithynian walls and archaeological sites dating back 8500 years. The goal was to contribute to the urban documentation by bringing attention to these restoration projects (Haberler, 2013).

During the Silk Road Conference held in Gaziantep on March 4, 2014, Prof. Dr. Metin Sözen, a member of the Board of Directors of the Turkish Historical Cities Association, expressed the intention to establish a "City Museum" in collaboration with municipalities in every city along the Silk Road. The aim, as stated, “is to revive cultural and historical values that have been on the verge of oblivion along the historic Silk Road, transporting them from one continent to another and sharing them with people worldwide.” (Gaziantep Belediyesi, 2014).

The "Silk Museums International Conference" was held in Valencia from November 15 to 17, 2018. Officials from silk museums in Spain, Italy, France, Georgia, Kazakhstan, Sweden, and Turkey participated in this conference held in Valencia, recognized by UNESCO as the European Silk City. Alongside the revitalization of Silk Road studies, the entrepreneurial efforts and planned reproduction of textile materials produced in the past have come to the forefront. Collections related to the Silk Road are housed within ethnography museums, city museums, and history museums. Since the year 2000, numerous Silk Road museums have been established in various locations traversed by this historical route (Univercity of Valencia, 2023).

The history and characteristics of Silk Museums worldwide were explored through an interdisciplinary perspective in collaboration with UNESCO Silk Road Online Platform, the International Council of Museums (ICOM), the International Society for Education through Art (INSEA), the Valencian Institute of Modern Art, and Valencia University. Officials from silk museums in Spain, Italy, France, Georgia, Kazakhstan, and Sweden participated in the conference held in Valencia, recognized by UNESCO as the European Silk City (Univercity of Valencia, 2023).

At the conference attended by experts within the framework of the UNESCO Silk Road Program, named "Silk City 2016-2020," the International Silk Museums Network is being established with the aim of generating long-term projects and fostering collaborations for Silk Road museums. This initiative seeks to bring together international experts to create a network for Silk Road museums. Additionally, the "KIMEP International Research Conference," focusing on economic integration along the New Silk Road, addresses global challenges, including those impacting all of us, and emphasizes the creative and innovative economic adaptation faced by Central Asia.

The Silk Road is a road network that contributed to the achievement of a civilization divided into South and North. Important cities on this route include Xi'an, Urumqi, Kashgar, Tashkent, Samarkand, Almaty, Tehran, Baghdad, Aleppo, Damascus, Mosul, Athens and Venice. In Turkey, cities such as Antakya, Gaziantep, Antalya, Trabzon, Nevşehir, Bursa and Edirne are also located on these roads. There are also special administrative units such as İpekyolu Municipality (Halkbank Culture and Life, 2020).

Examples of Silk Road and Silk Museum Projects in Turkey

In 2015, member cities of countries along the Silk Road reached agreements and signed protocols on commercial, economic, scientific, technological, and cultural collaborations. Leading this initiative from Turkey, the cities of Gaziantep and Bursa have been pioneers in fostering cooperation along the Silk Road (Gaziantep Belediyesi, 2014).

- **Trabzon Silk Road Museum**

A Silk Road Museum shedding light on the rich history of Trabzon, spanning 4000 years, has been opened by the Trabzon Chamber of Commerce and Industry. The establishment of the museum has received support from the Ministry of Development and the Eastern Black Sea Development Agency. The museum showcases a collection predominantly from the 16th and 18th centuries, belonging to the significant Ottoman and Seljuk periods, which hold great cultural value for the region. The collection includes a majority of Qur'ans, Icazetname (diplomas), Fiqh Books, Manuscripts, Calligraphy Tablets, along with metallic artifacts, silverware, and ornate bowls and inkwells. The historical artifact collection in Trabzon and its surroundings has been preserved, with 136 pieces from the 16th and 18th centuries being exhibited (Anadolu Ajansı, 2015).

Figure 1. Trabzon Silk Road Museum

Source: Anadolu Ajansı, https://www.aa.com.tr/tr/kultur-sanat/ipek-yolu-muzesi-ile-tarihe-yolculuk/68583.

- **Bursa Silk Museum**

Within the Merinos Textile Industry Museum, the Silk Museum narrates the journey of silk with the aim of preserving silk culture. The museum exhibits all stages of silk production, from the cocoon to the fabric. Established by the Bursa Metropolitan Municipality, the museum not only aims to sustain silk culture but also introduces the history of silk production at the Merinos Factory, such as the functioning machinery dating from 1938 to the 2000s, to future generations. The machines from the Merinos Factory, which operated between 1938 and the 2000s, have been restored and displayed in working condition. The museum provides a comprehensive view of all stages of silk production, from the cocoon to the fabric. Additionally, the museum is actively engaged in selling products manufactured on-site, contributing to the revitalization of silk culture (Bursa Büyükşehir Belediyesi, 2012).

In the jointly authored article titled "Preservation of Bursa's Industrial Heritage Related to Silk Production" by Zeynep Ahunbay and Elif Özlem Oral, the focus is on Bursa, an ancient silk production center along the historical Silk Road. The article delves into the historical urban fabric of Bursa, which was a prominent silk center. Bursa's past in silk production reveals the presence of 11 silk factories dating back to the 19th and 20th centuries. These silk factories, located in the Muradiye, Demirkapı, Mecnunde, Umurbey, and Karaağaç neighborhoods within the 19th-century urban fabric, hold significance in terms of technological history. However, with the abandonment of silk production activities in the city after the 1980s, these factories are at risk of disappearing due to neglect of industrial heritage. The rapid population increase in Bursa since the 1960s has led to a significant transformation of the historical urban fabric into commercial and densely populated residential areas. This transformation poses a threat to the destruction of historical and cultural values in the city (Tekeli, 2000; Ahunbay, Oral, 2005, p. 2).

- **Bursa Koza Mektebi, Silk Cocoon Cultivation Institute**

Historical records indicate that 15th-century Bursa was a fashion center equivalent to today's Milan, exporting silk fabrics worldwide. The Bursa Silk Production and Seed Cocoon Production School also played a role in this industrial and urban transformation. Established in 1838, it was the first silk spinning factory powered by steam. In addition to the factory established in the neighborhood named Silk Production (İpekçilik), in 1845, another larger silk spinning factory was established. The Seed School, constructed in collaboration with the Japanese in 1884, was a structure designed for the production of silk cocoons. Here, education was provided on the entire journey of valuable Bursa silk production, starting from the seed to the life of the silkworm. The Seed School, also known as the Silk Cocoon Cultivation Institute, has played a significant role in the history of Bursa's silk industry (Selma Erdal, 2020).

Figure 2. Bursa Koza Mektebi, Silk Cocoon Cultivation Institute, 20.8.1949

Source: Fethiye Erbay, Personel Archieve, 2023.

The Seed School, focusing on seed production and silkworm feeding, has educated a total of 5,000 students since its establishment, with the first foreign student enrolled in 1897. Celal Bayar is also among the graduates of this school. The institution has trained experts for Europe and Central Asia. The Silk Cocoon Cultivation Institute (Seed School), with its structure struggling to stand up to the present day, should be restored and transformed into a silk museum.

- **Bursa Umurbey Silk Production and Design Center Living Museum Project**

In 2015, the Umurbey Silk Production and Design Center began operating as part of the "Reviving Bursa Silk" Project. The facility is located in the Umurbey neighborhood of Yıldırım district. The center presents the history of Bursa Silk, which adorned palaces worldwide, to visitors in great detail. Within the facility, there are promotional areas where various narratives, exhibitions, and shows take place. There is also an exhibition area where silk and silk products produced in rural workshops connected to the center are displayed, weaving workshops where silk carpets and fabrics are woven, a warping and twisting workshop, a library, and a design workshop where patterns that bring silk to life are created. Additionally, on certain days of the week, the traditional method of silk reeling is demonstrated to visitors at the Umurbey Silk Production and Design Center (Bursa, 2015).

Figure 3. Bursa Umurbey Silk Production and Design Center

Source: Online, https://umaymdt.com/tr/portfoy/umurbey-ipek-uretim/

- **Söğüt Historical Silk Factory Living Museum, Museum-Factory Project**

Located within the borders of Söğüt district in Bilecik, the building that once operated as a Silk Factory and Cocoonery has lost its function over time due to the cessation of silk production. Sources indicate that there were a total of 11 silk enterprises in Bilecik, including 4 in Söğüt, in 1906. The only surviving operation that has reached the present day is the Söğüt Silk Factory and Cocoonery complex. Due to the effects of World War I, the region's occupation, and advancements in technology, sericulture has lost its significance compared to the past. Proposals have been made for the reuse of industrial heritage by transforming the Söğüt Silk Factory and Cocoonery into a museum (Öztürk and Aytaç, 2021, p.136-154).

It is proposed to revitalize the building by giving it a new function, transforming it into a living museum. In order for the industrial heritage building to establish a connection with future generations and ensure sustainability, it should be designed with a post-modern approach, focusing on experiential aspects, and strategically planned for transformation into a 'museum-factory' structure (Öztürk and Aytaç, 2021, p. 136-154).

- **Edirne Kozahane and Cocoon School**

The historical Kozahane Building in Edirne, located on the Silk Road, can be transformed into a Silk Road Museum through restoration. Situated in Dilaver Bey Mahallesi, across from the Dar-ül Hadis Mosque, this historic building, Kozahane, was constructed in the early 20th century in the Kaleiçi region of Edirne. In 1905, a major fire in the Kaleiçi area resulted in the destruction of part of the region. Following the fire, the Edirne Municipality prepared a new urban plan for the Kaleiçi district, and Kozahane was built during this period. The building, which was transferred to the Treasury in 1980, came under the ownership of the Koza Agricultural Sales Cooperative Union in 1991. Although the building was temporarily transferred to the Edirne Chamber of Commerce, it returned to the ownership of the cooperative due to non-utilization. The Koza-Böcek (Silk-Cocoon) school, under the service of the Diyanet (Religious Affairs) and restored by the governorship, is part of this complex (Edirne Medya, 2020).

Figure 4. Edirne Kozahane Building

Sources: Edirnemedya, [https://www.edirnemedya.net/edirne/sahipsiz-kaldi-harabeye-dondu-h2791.html], 13 temmuz 2020); Mutlu Erbay, Personel Archieve 2023).

By revitalizing and repurposing these two historical buildings, the Kozahane and Cocoon School, they can be transformed into silk production areas and contribute to cultural tourism by becoming a Silk Museum. Additionally, Edirne city can be crowned with the title of Silk City. Located at the heart of cultural industry, these establishments, along with the Edirne Silk Road Museum, will revitalize cultural forms. I hereby declare my voluntary commitment to the project of establishing the Silk Road Museum in Edirne as the President of the International Silk Road Museum Association. Furthermore, the museum should include Edirne's historical archive and reflections on the traces of Edirne Red. Edirne residents will continue to explore the lost cultural heritage and traces of Edirne Red in the museum.

Examples of Silk Road-Silk Museum Projects from Abroad

In recent years, global efforts have been underway to preserve 20th-century heritage. One of the most significant initiatives is the Montreal Plan (MP20), developed by the International Council on Monuments and Sites (ICOMOS) since 2001 (ICOMOS International Secretariat, 2002). MP20 aims to assist in developing strategies for the preservation of monuments related to 20th-century architecture. In a survey organized worldwide by MP20, the ICOMOS Turkey National Committee suggested the inclusion of industrial structures within the scope of 20th-century heritage in Turkey (ICOMOS, 2015, p. 8).

In recent years, the Working Group of the Council of Europe has been developing cultural tourism projects to showcase the industrial heritage related to sericulture in Europe. The aim of these projects is to exhibit cultural heritage elements, industrial heritage structures, and original machinery found in structures along the routes known as the 'Silk Road.' Activities are underway in Italy, the United Kingdom, France, and Spain to revive travel routes (Zanier, 1999; Ahunbay, Oral, 2005, p. 9)

- **The Valencia Silk Museum Project, Spain**

The city of Valencia in Spain is historically significant for the production and trade of silk textiles. In the 9th century, Valencia became a prominent city for silk cocoon trade thanks to the Arabs arriving on the Iberian Peninsula. Those engaged in silk production in Valencia, in 1479, organized themselves for the first time by accepting the rules of the Velluters Guild, consisting of velvet weavers. The current building, constructed between 1482-1492, had its land acquired in 1494. Valencia became the center of silk production with 5,000 looms. The building played a crucial role in the economy of Valencia in the 15th century, based on silk cocoon and weaving trade. By the late 1500s, Valencia had become very wealthy due to silk production and trade. In 1686, King Charles II converted the Historical Silk Guild Building into the High Silk Art School. The Historical Silk Guild Building is one of the city's most important architectural features, representing both a fortress and a civilian structure, making it architecturally significant. Between the 16th and 18th centuries, La Lonja de La Seda became the development center for Valencia's silk industry and trade. Under the ownership of the college, silk studies were conducted and developed for many years. The historical building of the Silk Art College, located in the historic center of Valencia, was converted into a museum in 2016. The museum exhibits valuable fabrics, weaving looms, and tools showcasing the technology of the time. In its first month, the museum was visited by 6,000 people (Museums Delle Seda, 2023).

Figure 5.Valencia Silk Museum, Spain

Source: Museo de la Seda Valencia, https://www.museodelasedavalencia.com/en/museum/.

During this century-long period, it became one of the most important cultural and trade centers in Europe. The stock exchange building was constructed during that era. The building, dating back to the 15th century, features an eclectic architectural style blending Gothic and Baroque influences. In the 18th century, a silk factory was established here (Colegio Del Arte Mayor De La Seda, 2023).

From 2007 to 2009, restoration work was carried out to reclaim the old building. This structure, designated as a national historic monument requiring preservation for cultural heritage in 1981, was officially opened as a museum on June 18, 2016. In 2015, as part of the UNESCO Silk Road program, the collective efforts of 32 member states led to the declaration of Valencia as the Silk City in 2016 (UNESCO, Valencia, 2023).

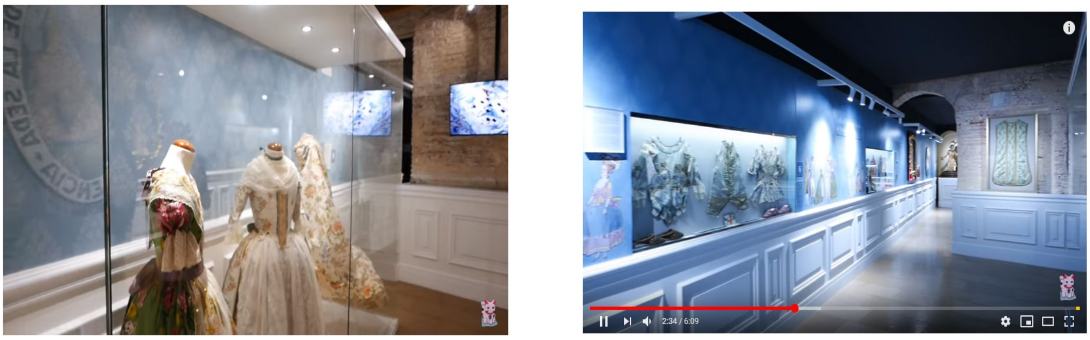

Figure 6-Valencia Silk Museum, Spain

Source: Youtube, https://www.youtube.com/watch?v=BbhKq4RVD68.

In the museum, examples of traditional costumes worn in today's festivals in València are also exhibited. The museum showcases the processes from ancient weaving looms to the breeding of silk worms, tracing the evolution of silk from its cultivation to woven samples. It is significant for portraying the pre-industrial and post-industrial processes of textile development on València's lands, displaying its commercial values and mass cultural productions. Documents covering trade agreements and all aspects of trade related to business and social processes in 15th-century València are found in the museum. The economic history of València is read through these archival documents in the museum. The Tourism Department of València has begun investing in reviving silk production, focusing on the Silk Road as one of the main attractions that València should have. The museum has a wonderful restaurant. Various events, concerts, and presentations take place in the museum's garden and café. There is also a gift shop where items made with València silk are sold (Times Higher Education, 2023).

- **Valencia University Textile Museum, Spain**

In 1499, Valencia University initiated a project to transform its storage halls into a Textile Museum, led by the chair of the Museum Studies and Cultural Heritage undergraduate program and its students. Over a 6-month period, they successfully collected materials and established the museum's collection. (Times Higher Education, 2023). On March 25, 2014, the Textile Museum of Valencia University was opened (University of Valencia, 2023).

- **Como Silk Education Museum, Italy**

In the region where Lake Como is located in Italy, it is significant for being a place where textile machinery, especially looms, is produced. The history of silk production in the region dates back to the 16th century. In the 19th century, the "Setificio School" became the most important sector in Italy. The Monti Civic Silk Factory has been transformed into the Silk Museum. In 1869, a second structure was built next to a yarn factory for the cultivation and spinning of silkworms. In 1934, the operation of the silk factory came to an end, and later the facilities of the factory were transferred to the private sector. A factory for aluminum production was established in its place. The Como region is important for being a place where textile machinery, especially looms, is produced. Since 1981, efforts have been made to develop Monti Civic Silk.

After 1980, factories had the advantage in textile production, leaving their place to production and demolition. To prevent the abandonment of these regions, local governments have conducted studies.

In 1985, with the start of the Association of Setificio in Como collecting materials related to silk factories, the foundation of museum studies was laid. In 1988, with the opening of the "Permanent Findings Exhibition of the Historical Findings of the Silk Industry," the first works were introduced to the public. A Museum Establishment Committee was formed for the purpose of establishing the Silk Museum. From 1994 to 1998, numerous machine and instrument donations were made to the museum, which was to be opened in 1990. With the establishment of the University and the Milan Polytechnic Institute, projects were initiated to develop studies in the field of the silk industry (UNESCO, Valencia, 2023).

- **China National Silk Museum**

The China National Silk Museum building covers an area of 8,000 square meters, making it the world's largest silk museum with a total area of 50,000 square meters. The museum features exhibits such as "The Story of Chinese Silk," "Silk Production and Sericulture in China," "Weaving Conservation Gallery," and artworks showcasing the modern uses of silk in China. Each silk garment is presented with interesting stories and historical facts. In a separate section of the museum campus, there is a restoration department. Workshop activities are organized for children to paint silk fabrics. Silk weaving and dyeing classes are also offered to children and students of different ages.

Established in 2000, the museum was expanded in 2010 with the addition of the China Weaving Identification and Conservation Center. The center is currently engaged in significant research and activities in this field. The China National Silk Museum is an important institution for textile collection, exhibition, preservation, research, and education. The section where silk products are woven and dyed includes both large and small weaving looms. The museum also collaborates with museums abroad, organizing temporary exhibitions in addition to hosting permanent exhibitions.

The China National Silk Museum presented the exhibition "Silk Road - 2000 Years of Cultural Heritage Between East and West Asia" in Izmir from July 28 to August 14, 2015, in collaboration with various museums (İzmir, 2023).

- **Soufli Silk Art Museum, Greece**

Operating under the responsibility of the Piraeus Club Foundation, the Soufli Silk Art Museum is housed in the neoclassical Kourtidis Mansion, dating back to 1886, located in the center of Soufli. The building underwent restoration and reopened in September 2008. The museum provides information about the history of natural silk and its journey from China to Europe (EmtGreece, 2023).

Figure 7. Soufli Silk Art Museum, Greece

Source: Fethiye Erbay, Personal Archieve, 2023.

The Silk Museum provides a detailed presentation of sericulture and the various stages of silk production. It features videos showcasing the stages from raising silkworms to the finished silk product. The goal of the Silk Art Museum is to emphasize and preserve the rich tradition of silk production in the region. Using state-of-the-art technology, the museum exhibits original displays illustrating the production process to visitors. In addition to silk-related exhibitions, the museum also hosts various artistic and cultural events. The museum shop offers a wide range of local and traditional products from Tsiakiri's silk house collection. Equipped with a unique electronic multilingual guide system, the Silk Art Museum ensures accessibility for individuals with disabilities, providing entrance ramps, elevators, and accessible facilities (E-evros, 2023).

CONCLUSION

Museums are venues that host significant encounters for cultures, elevate awareness of historical preservation, and contribute to aesthetic concerns. Serving as bridges between the past and the future, museums house the historical and cultural heritage treasures of cities. Within the context of Silk Road museums, archives of textile, ethnography, urbanism, history, and technology museums are also exhibited. These institutions play a crucial role in documenting and reviving past production models, as well as advancing the production processes of textiles. Simultaneously, they inspire new forms through their productions, contributing to the fashion industry with contemporary designs. The revival of silk production and traces of technological and fashion-related developments can be observed in Silk Road museums.

International Silk Road studies and the preservation of industrial heritage support the opening of Silk Road museums in these architectural transformation projects. Silk museums in European silk production centers that showcase the silk history of cities are transformed into unique design spaces. In Turkey, along the Silk Road route in cities like Bursa and Edirne, silk production areas should be projectively transformed into preserved, living Silk Road museums. Former production areas and old silk factories will provide visitors with experimental practices as museum spaces. The planned Silk Road Museums should exhibit the process of transforming silk from cocoon to fabric. Various types of production, such as silk carpets, textile weaving courses, exhibitions, and events, should be included as educational areas in museum workshops.

Silk Road Museums have rapidly gained momentum through networks established among museums and museum professionals. The cultural transfer from regions traversed by the Silk Road finds exhibition spaces in new Silk Road museums. The revitalization of Silk Road studies, the opening of international exhibitions, conferences, academic studies, and international agreements will pave the way for the opening and increasing numbers of Silk Road museums.

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IN THE TOPKAPI PALACE COLLECTION REFLECTION OF THE SILK ROAD

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ABSTRACT

The Silk Road, the longest highway of the ancient world, hosted different cultures for thousands of years. Connecting different geographies, it brought economic prosperity and political supremacy to the regions it passed through. The Silk Road trade, extending from China to the Mediterranean coasts, fostered a competitive environment in the countries it traversed. The transit route of the Silk Road witnessed relentless cultural, economic, and political hegemony struggles between the Turks and the Chinese for about a thousand years until the mid-9th century. The symbolic trade product of this historical route was silk, and silk was not just a product bought and sold. It was a capital element that functioned as currency within the thousands of square kilometers of this route. Not only silk but also many cotton and felt goods were transferred from the Silk Road. The dyeing of these fibers required materials such as natural dyes and plant-based colors. Silk, fur, and spices coming from the Far East played a significant role in international relations for the Western world.

In the Middle Ages, trade caravans would depart from the present-day city of Xi'an in China and reach the city of Kashgar in Uzbekistan. Here, the route would split into two paths: one through the plains of Afghanistan to the Caspian Sea and the other crossing the Karakoram Mountains to reach Anatolia via Iran. In Anatolia, goods would either be transported by sea or by land through Thrace to reach Europe. Until recent times, it was believed that there was only one route between the East and the West. However, nowadays it is possible to talk about three main routes and perhaps even a larger network of routes. While it seems difficult to know the complete route of the Silk Road, experts are attempting to determine a specific route today based on

archaeological findings, ancient roads, technological satellite images, photogrammetric applications, and historical sources. Transportation on the Silk Road was facilitated by caravans and camels, with stays in inns. Edirne is one of the cities located on the Silk Road. Therefore, it can be assumed that the color produced painstakingly with root dyes known as 'Edirne red' was used in goods dyed in Silk Road caravans.

INTRODUCTION

This research is based on an examination of the Topkapı Palace Museum collection and relevant literature in the field. Our aim is to elucidate the future prospects of the Silk Road and its impact on the city where it is situated by scrutinizing publications, literary works, and didactic tutorials that unveil the historical imprints of the Silk Road. Given Edirne's location along the Silk Road, its role and significance within the trade network are paramount. Notably, the utilization of red dye, such as Edirne red, has been a subject of registered research and holds great importance in dyeing numerous fabrics. It is evident that Edirne red was employed in textiles during that period, underlining its commercial significance. It is believed that this red dye from Edirne was utilized in various products, including woven and knitted fabrics, felt, as well as linen and silk fabrics. However, the specific methods of its application and integration into weaving are currently under investigation.

It is plausible that a multitude of valuable items were imported via the Silk Road, particularly to key locations such as the Edirne palace, Bursa, and Topkapı palaces. Yet, the extent to which these artifacts have endured to the present day remains uncertain. Diverse artifacts may be held by local inhabitants, which, while lacking expensive silk, have managed to persist through time.

The perception that the value of textiles is directly tied to the cost of materials employed prompted the Ottoman sultanate to utilize fur, silk, precious stones, pearls, gold, and silver textiles subsequent to its establishment. Craftsmen for the Ottoman palace were selected from the public, and artists from conquered territories were brought to Istanbul and engaged in the workshops of the Enderun, Ehl-i Hiref, and Karhane-Kassa regiments within the palace to fulfill its needs. This practice resulted in a clear distinction between palace art and popular or folk art (Uğurlu, p. 165).

Following the conquest of Bursa, the Ottomans assimilated the palace lifestyle of their neighboring region. During the reign of Orhan Bey, opulent clothing and textiles, including silk, began to replace traditional attire. Mansurizade Mustafa Pasha from Izmir, in his work Netayicul Vukuat, noted that Yıldırım Khan adorned himself in clothing with gold buttons woven with gold and silk threads. Historical records indicate that while Yavuz Sultan Selim adopted a modest and unadorned Bektashi style of clothing, his son Suleiman the Magnificent favored elegant and ostentatious apparel (Uğurlu, p. 165).

Figure 1. Edirne Cocoon Factory Chimney Karaağaç

In connection to the Edirne Palace and its association with silk, the presence of the Edirne Cocoon Factory, marked notably by its chimney in Karağaç, and the Edirne Cocoon School holds significant relevance in illustrating the state of the weaving industry during that era. Additionally, one should bear in mind that the Silk Road traverses the Edirne road of Trakya University. Remarkably, the remnants of the Silk School, the cocoon factory, and the chimney within the cocoon production area remain intact to this day.

Figure 2. Edirne Cocoon Factory

Ottoman Palace: The conquest of Istanbul in 1453 marked a pivotal moment for the Ottoman Empire, as it acquired control over the Silk Road trade. In the classical period of the Ottoman Empire, significant developments occurred in the domain of silk weaving across various regions of Anatolia, including Eskişehir and Bursa. These regions became centers for silk weaving, contributing to the production of high-quality silk fabrics.

Silk textiles held paramount importance, not only for their inherent quality but also for the symbolism they carried. The fabric's quality transcended its material properties, signifying class, wealth, and political power. It became a tangible representation of one's affluence and social status within Ottoman society. Thus, the production and trade of silk textiles played a crucial role in shaping the socio-political landscape of the Ottoman Empire during its classical era.

Figure 3. Edirne Cocoon School

Topkapı Palace, constructed by Mehmet the Conqueror on a Byzantine acropolis in 1478, stood as the administrative epicenter of the Ottoman state for an impressive span of 380 years. Upon its inception, it encompassed a sprawling area of 700,000 square meters; however, in its present state, the palace endures across a reduced expanse of 80,000 square meters. Nestled in Sarayburnu, Istanbul, the palace initially transitioned into a museum open to visitors during the reign of Sultan Abdülmecid. On April 3, 1924, under the directive of Mustafa Kemal Atatürk, it was unveiled for public visitation and affiliated with the Directorate of Istanbul Antiquities Museums. Initially serving as the Treasury Secretariat and subsequently as the Treasury Directorate, today it functions under the purview of the Topkapı Palace Museum Directorate.

Within the Ottoman palace ceremonial Kaftans, various weaving types were commonly employed. These encompassed seraser, kemha, çatma, golden stringed çatma, velvet atlas, serenk sevayi, telli sevayi, hatai, trip, selimiye, kutnu, and çuha. Ottoman clothing bore profound significance in the realm of social life, where the color and fabric of the garments conveyed nuanced meanings, reflecting the societal status of the wearer. Regardless of an individual's position, attire underwent alterations based on the occasion and time of wear. Red emerged as the predominant hue in the ceremonial robes of the Ottoman Palace. Additionally, a palette featuring colors such as blue, green, yellow, cream, white gold, honey, and pistachio green was employed in the intricate weavings. During the 16th and early 17th centuries, the number of colors utilized in the weavings typically did not surpass seven; nevertheless, a polychromatic effect was achieved through masterful design and motif-contour relationships (Uğurlu, p. 166-167).

Topkapi Palace Museum: Topkapı Palace served as the official residence of the Ottoman sultans from the era of Mehmet the Conqueror (1451-1481) up to the reign of Sultan Abdülmecit (1839-1861). Following Sultan Abdülmecit's relocation to Dolmabahçe Palace, Topkapı Palace underwent a shift in function, becoming a venue to host incoming diplomats and ambassadors. However, the challenge arose of reorganizing and concealing the items designated for display to visitors before each visit. To address this issue, Sultan Abdülmecit advocated for the prominent and valuable pieces to be placed in showcases and exhibited in this manner. This initiative marked the inception of the initial museum movement within the palace.

Subsequently, with the occupation of Istanbul in 1919, Topkapı Palace was temporarily closed to visitors. However, the tide turned in 1923 when the Government of the Republic of Turkey made the historic decision to convert the palace into a museum, preserving its rich heritage for posterity. The transformation into a museum not only ensured the conservation of its artifacts but also facilitated public access to the cultural treasures within its walls. Moreover, the Topkapı Palace Library stands as a repository of approximately 20.000 works spanning diverse fields of knowledge. Notably, during the reign of Bayezid II (1481-1512), a significant effort was made to compile numerous books, marking a pivotal moment when an inventory of these books was meticulously cataloged for the first time.

Silk Weaving Samples in Topkapi Palace

One of the most significant treasures housed within Topkapı Palace is the Sultan's clothes collection, which stands as a pinnacle of Ottoman weaving artistry. This collection showcases an opulent array of garments primarily crafted from silk textiles and other precious fabrics. It encompasses the clothing worn by sultans and princes from the latter half of the 15th century to the early 20th century. The dress collection came into being through a longstanding tradition of carefully preserving and storing the clothes of sultans and princes in bundles, complete with labels, following the demise of dynasty members. These garments were then preserved as cherished mementos in the Palace treasury. Today, a considerable number of these unique garments, fashioned from silk fabrics, remain remarkably well-preserved, bearing testament to the exquisite craftsmanship of the bygone Ottoman era.

Figure 4. 16th century Prince's Silk Robe in Topkapi Palace (at.no.105) Processed by Ahmet, Islamic Culture and Civilization, MEB, p. 97.

The ceremonial caftan with a turned collar, dating back to 1483, belonging to Prince Korkud, son of Bayezid II, represents a notable early ceremonial caftan within the esteemed collection of Topkapı Palace. This piece stands as an exemplary representation of the exquisite ceremonial attire worn during that era. Sibel Alpaslan Arça, in her publication titled "Sultan Robes Collection," featured and highlighted this particular caftan as a significant artifact within the rich tapestry of the Topkapı Palace Museum. The publication sheds light on the historical and cultural significance of the Sultan Robes Collection, offering a glimpse into the opulent world of Ottoman ceremonial attire and the legacy it embodies.

Figure 5. Sibel Alpaslan Arça; Publication titled “Topkapı Palace Museum Sultan's Clothes Collection”

Here, as a unique example, II. It is also worth mentioning Selim's serasker caftan, decorated with large sun motifs, and the 16th century kemha caftan with a two-thread interlaced pattern, belonging to Bayazid II. The ceremonial robes used by the Ottoman Sultans in official, religious and private ceremonies reflected the status, magnificence and taste of the sultan. The richness of materials, techniques, applications and decorations used in kaftans gives information about the period in which they were made. The ceremonial robes of the Ottoman sultans reflect the technology of the period, artistic tendencies, needs, tastes and lifestyles of senior administrators. (Uğurlu, p.172) Topkapı Palace contains important collections of the Silk Road, especially in clothing and utility items. Examples of textile, textile and porcelain utility items are world famous. There is no doubt that textile and porcelain works came to Topkapı Palace via the Silk Road.

Topkapi Palace Porcelain Samples

Although there is no information about all the works in the Topkapı Palace that came via the Silk Road, works sent from China and Japan have been identified in the palace collection. The route of arrival of these works is, of course, the Silk Road.

Chinese Porcelain: With the Tang Dynasty (618-907) dominating China, porcelain production began to achieve the same success it had in other arts. Fağfuri is the name given to Chinese porcelain by the Ottomans and comprised an important part of the palace collection. The period when these porcelains first started to be used in Anatolia dates back to the 14th century. Corresponds to the century. There are complete collections of Chinese porcelain in the Topkapı Palace.

Japanese Porcelain: The Japanese porcelains exhibited in the museum are from the 17th and 18th centuries. Since they date back to the 19th century and were made for export purposes, they do not bear much Japanese decorative art. European Porcelains These are around 5000 pieces and among them are the III. It is a porcelain set that Napoleon sent to Sultan Abdulmecid I, and this is the most valuable piece of the collection. Among other European porcelains, there are porcelains made by well-known artists from Meissen and Vienna. Istanbul Porcelains and Glass Works These are 900 pieces in total. Sultan II. They were produced in the Yıldız Tile Factory established by Abdulhamid within the Yıldız Palace. Glass works were completed in the 18th century upon the request of the sultans. It started in the century. Sultan II. Selim sent a Mevlevi named Mehmet Dede to Italy to learn glassmaking, and upon his return, production started in the workshop in Beykoz. The first days of Yıldız Tile Factory (Önder Küçükerman archive)

The Silk Road is a trade route that stretched from China to Europe for centuries. But it has served as a bridge between civilizations not only economically but also scientifically, culturally, religiously and intellectually. Through the Silk Road, many works of art reached many kilometers away and different aspects of art were influenced by each other. For example, it is understood that many cultures on the route of the Silk Road were influenced by the paintings signed by Muhammed Kara Kalem. Visualization of lifestyles and products used together with painting allows us to understand them better. Thanks to these pictures, we get more detailed information about religions and ancient daily lives. In addition, with these paintings we see not only real objects but also drawings of supernatural beings. These pictures are carried in rolls because this is one of the most ideal methods for travelling. Although some of it was lost on the way, it reveals the beliefs and lifestyle of Shamanism, Chinese culture and Mongolian culture. With this journey extending to Europe via the Silk Road, empires such as the Ottoman and Byzantine gained knowledge about distant cultures and protected these works. (Yasa, 2016) Many other cultural and artistic works like this went on a long journey and were found in different parts of the world. Had the opportunity to be recognized.

Development Process of the Silk Road

Following the conquest of Egypt, the Ottoman Empire acquired control over two pivotal trade routes-the Silk Road and the Spice Road-amplifying their economic influence. Later, the Fur Road was integrated into this network of trade routes. The Ottoman Empire's domination of the eastern trade routes spurred exploration and the quest for new trade avenues in Europe, marking the onset of significant geographical discoveries (Erbay, M.).

The year 1487 witnessed the discovery of the Cape of Good Hope at the southern tip of Portugal, a pivotal development in maritime exploration. Subsequently, Christopher Columbus set sail from the Spanish port of Palas and discovered the American Continent in 1492. In 1498, Portuguese explorer Vasco da Gama successfully reached India by circumnavigating the Cape of Good Hope. This newfound dominance of the Indian Ocean by the Portuguese altered the course of the Spice Route, prompting it to shift towards the Cape of Good Hope, now under Portuguese control. This shift ignited the Ottoman-Portuguese struggle in Indian waters.

The advent of these geographical discoveries had profound ramifications for Islamic countries. They experienced a decline in wealth, and the Turkestan Khanates gradually weakened and faltered in the face of Russian encroachment. Despite Ottoman Empire's dominance over the Silk and Spice Roads, the alteration of trade routes weakened their trade standing. Consequently, the Ottoman Empire had to concede capitulations to European states to revitalize its trading activities. Furthermore, the populace and artisans operating along the caravan routes within Ottoman territories found themselves unemployed, setting the stage for economic hardships and the outbreak of the Celali Rebellions.

CONCLUSION

Topkapi Palace holds immense historical significance, bearing witness to a rich and diverse past. The Topkapi Palace Museum boasts an exceptional inventory, particularly notable for its collection of textiles and porcelain, which have historical roots tied to the Silk Road. This underscores the significant role played by the Ottoman Empire in the trade dynamics of the period.

Within the Silk Road's expansive network, any collection featuring red textiles and porcelain holds great importance. Edirne red, renowned for its usage in numerous fabrics and textiles like straw, made a lasting mark on this ancient trade route. Examining these examples provides valuable insights into dye technology, silk production methods, and porcelain casting techniques, offering a unique window into the era.

In the present day, shifting global dynamics and new geopolitical balances have once again underscored the significance of the Silk Road. Post-1989, the newfound independence of the Central Asian Turkish Republics elevated the commercial importance of the Silk Road. The Modern Silk Road Belt Project, initiated in 2013, aimed to rejuvenate this historic trade route, recognizing its cultural and historical value. Leading nations like Kazakhstan, China, and Turkey have actively participated in this revitalization effort, striving to preserve and repurpose antiquated buildings along the route. The Silk Road projects, categorized into sea, railway, and road initiatives, have seen substantial investments and planning since 2014.

Looking ahead, the Chinese Communist Party's ambitious plans, outlined in a progress report extending to the 2070s, indicate intentions to economically rejuvenate the Silk Road. This new-generation intercountry road project will significantly impact arts, culture, and museum activities, fostering closer connections among people across nations, promoting cultural exchange, and shaping the future of international collaboration.

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LABOR RELATIONS NARRATED IN SABRİYE CEMBOLUK'S EDİRNE RED: PERIOD, GEOGRAPHY AND SECTOR

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ABSTRACT

Edirne Red is a color of historical importance, which involves a very laborious dyeing process. The Ottoman Empire became a center where the fabrics sent from Europe were dyed, or many master painters from these lands were sent to establish centers in Europe. Labor relations is a management function that regulates all economic, social and human relations between the employee and the employer due to employment, and includes the balancing of mutual rights and demands. Addressing Edirne Red production process, which also has close relations with the textile industry in England, the starting point of the industrial revolution, is also important in terms of Turkish labor relations history. The main objective of our study is to analyze how Edirne Kırmızısı, the novel, created a schema regarding the working relations. The fictional text has been analyzed with a qualitative approach. Thematic analysis produced nine major categories; and international competition, espionage, trade routes, artisan and artisanal process and working conditions themes are directly related to labor relations discipline.

Keywords: Labor Relations, Edirne Red, Narrative Analysis

INTRODUCTION

Edirne Red, also known as Turkish Red, is a color of historical importance, involving a very laborious dyeing process, for which a lot of effort and money were spent, and rewards were given to those who solved its secret (Yıldırım, 2014). The Ottoman Empire either became a center where fabrics sent from Europe, especially France, were dyed, or many master dyers from these lands were sent to establish centers in Europe (Lowengard, 2006).

According to Julie Wertz (2017), Turkish red is not a dye in itself, but a dyeing process. It is a vibrant and non-fading red tone that the cotton thread acquires by passing through many predefined stages. The researcher also stated that Turkish Red is “the most complex and laborious operation in the art of dyeing.” The two basic stages of the process are defined as mordanting and dyeing (Karadağ and Dölen, 2007), and the key points to ensure worker health and safety are explained. With these aspects, the question of what the Edirne red production process is like in terms of working life and working relations and what it involves in these terms comes to mind.

In this regard, it is aimed to draw a picture of the working relations of the period and geographies by taking as reference the texts related to the management, production and trade processes of Edirne red, which are written in Sabriye Cemboluk's novel Edirne Kırmızısı (Edirne Red in English).

TEXTILE INDUSTRY IN THE OTTOMAN

The industrial revolution, which started in the mid-18th century and symbolized the transition from muscle power to mechanical power, is one of the most important turning points in human history. It has not only changed economic life, but also caused significant changes in social life and the global trade chain. Factory-style production, which developed with the use of steam machines in production systems, enabled production quantities to increase at an unprecedented rate until that day, and caused unit production costs to decrease, thus providing an absolute advantage over traditional production methods. On the other hand, the increasing amount of production also increased the need for new markets, and in the face of the inadequacy of domestic markets, international markets began to become a competitive element for the first countries to realize the industrial revolution. In this process, developments in transportation technologies made a significant contribution to the formation of international markets by making it possible to transport cheap and abundant products to long distances. While all these developments represented absolute wealth for the central countries that carried out the industrial revolution, they triggered a process in which peripheral countries that produced with traditional methods could not compete with European products. In this process, local producers who could not compete with cheap goods were forced to close their businesses, and a period of increasing unemployment and poverty began.

For the Ottoman Empire, the Industrial Revolution has been discussed as one of the most important developments that accelerated the collapse process (Clark, 2009; Pamuk and Williamson, 2019: 5). International trade, which became more secure with the end of the Napoleonic era in Europe, accelerated the eastward flow of European goods. This situation started a process in which European origin products began to replace traditional Ottoman products, as in many other surrounding countries (Clark, 2009). In this process, England, which tried to gain foreign markets for its manufacturers with expansionist policies, started to sign free trade agreements with many countries, especially China and South America, between 1820 and 1840, by putting pressure on local governments (Eşiyok, 2010). The Baltalimanı Agreement, which was signed with the Ottoman Empire in 1838 and came into force in 1839, is one of them (Pamuk and Williamson, 2019: 5). Although this agreement was the first free trade agreement signed by the Ottoman Empire, free trade agreements were signed with different European countries in the following three years.

Weaving and Dyeing Industry in the Ottoman Period

Weaving is the dominant sector of the Ottoman Empire industry. Particularly, the suitability of its lands for cotton and small cattle cultivation and the spread of silkworm cocoon cultivation in certain regions played an important role in the development of weaving (Buluş, 2000: 51). Between the 15th and 17th centuries, textile products, including luxury silks, were exported from the Ottoman lands to many regions (Bektaşoğlu, 2021). The Empire, which was able to achieve self-sufficiency in the domestic market, was filled with Europe's cheap and abundant textile products due to the changing production systems with the industrial revolution. Traditional producers, unable to compete with these products, declined, especially in cotton weaving handicrafts, between 182 and the mid-1870s, and spinning production decreased from 11,550 tons to 8,250 tons in 1820 and to 3,000 tons in 1870 (Pamuk and Williamson, 2019). While there were 25 to 28 silk looms in Thessaloniki in 1850, this number decreased to 18 within 5 years. In the 1850s, textile products decreased to approximately one tenth in important production centers such as Bursa and Diyarbakır.

Depending on these developments, the number of full-time textile workers, which was around 288,000 between 1820 and 1822 and 2.08% of the total population, decreased to 104,400 between 1909 and 1911, or 0.41% of the population (Makal, 2012).

The main reason why the Ottoman Empire lost its superiority in textile production was undoubtedly its failure to realize the industrial revolution. Because the first sector to start mechanization with the industrial revolution was the textile sector. It is known that in the weaving industry, which was primarily affected by the developments caused by the industrial revolution, by the 19th century, 98% of the tasks performed by workers were done by machines (Bessen, 2015, p. 16). This situation led to a decrease in costs and a competitive advantage in textile production, especially in England, and in the mid-19th century, the Ottoman Empire lost the markets in which it had superiority. Beykoz Broadcloth Factory (1805), Malta Factory (1818), İplikhane-i Amire (1827), Feshane Defterdar Factory (1833), İslimiye Broadcloth Factory (1836), İzmit Broadcloth Factory (1839), Basmahane Factory (1844), established by the Empire. (1850), Karamürsel Şayak (1890) factories were negatively affected by competition and could not become permanent (Bektaşoğlu, 2021).

On the other hand, the fact that the plants used in dyeing, primarily called Turkish red, are widely grown in Anatolia is considered an important factor in the development of dyeing. XII. madder, which began to be cultivated in the 19th century , became an important item in tax and customs revenue in Europe over time. Germany was the leading country in madder dye production. However, the real fame of madder dyes came with Turkish red. As a part of the natural vegetation of Anatolia, it made the Ottoman Empire famous in dyeing. Another reason for the success in dyeing is that alum, which is an important ingredient for the dyes used in wool weaving, is produced in Foça, Ulubat, Kütahya and Şarki Karahisar. (Koç, 2009).

In the Ottoman Empire, the textile industry was an important commercial activity in different geographies of the Empire, especially in Istanbul. Bursa, Aleppo, Damascus, Chios, Thessaloniki, Tokat and Antep were important textile production centers and made significant contributions to the development of sub-sectors such as weaving production and dyeing (Öğüt, 2019; Çınar, 2013). Especially after the industrial revolution, until the use of industrial paints, paint shops had come to control the paint market with both quality production and production quantity. The fact that dyehouses have become an important income item has caused foundations to show interest and invest in dyehouses. Selatin foundations in Istanbul, Rızvaniye Foundation in Urfa, Hüsrev Pasha Foundation in Antep are among the most well-known of these foundationsn (Çınar, 2013; Öğüt, 2019).

LITERATURE AND LABOR RELATIONS

Labor relations is a management function that regulates all economic, social and human relations between employees and employers due to employment and includes the balancing of mutual rights and requests (Özçelik, 2022). In other words, it refers to a social and economic whole that extends from production to quality of life, as the basic infrastructure of economic life, within the framework of the rights, obligations, expectations, values and rewards that define the interactions in the labor market (Lowe, Schellenberg and Davidman, 1999: 2). In this context, one of the most important sources that help us understand the social dimension of labor relations is literary works. Literary works testify to work and work relations, which are one of the most important elements of social life, and serve important functions in giving meaning to work and transferring different geographical and cultural values between generations (Makal, 2008: 18) . In particular, works describing the poor working conditions that emerged with the industrial revolution are valuable sources in terms of literature and labor relations, and they provide important data to understand the labor relations of the period and pass them on to today's generations (Makal, 2020: 4).

Employment relations in Turkish literature has taken a place in a relatively late period. While this situation can be attributed to many reasons, in particular, oppressive policies in the economic, social, legal and political fields and the delay of the industrialization process are considered among the important factors (Makal, 2020: 5). It is possible to find clues about labor relations in novels, of which limited examples are found in the Ottoman period (Man, 2020). In this context, when we look at the totality of works on labor relations in Turkish literature, it is seen that, although there are a very limited number of them, the works focus on the negativities in the working conditions of workers and social struggles are not included much (Makal, 2020: 6). On the other hand, there are few examples of the use of Turkish literature, and even popular musical works such as songs, in labor relations, labor history and management literature (See Tilbe and Tilbe, 2015; Güler, 2016). Ahmet Makal made the most important evaluation on this subject with his article titled 'Literature' as a Projection Area of Turkish Labor History (2008). In this article, he mentions that; through studies on the history of literature and working life, it is possible to " *to determine some general trends in quantitative and qualitative terms; and on the other hand reveal the economic, political, social and cultural factors affecting these trends and to reach some evaluations as a result"*(Makal, 2008).

The use of all narratives, including literary texts, in labor history studies brings with it some methodological problems, especially the lack of objectivity (McCartney and Turnbull, 1953; Makal, 2008).

Historical Novel

The 'turn to narrative' movement argues that narratives are valuable for qualitative research, and as a result of this trend, the use of narratives in social science research has increased significantly (Czarniawska, 2004). According to Türkeş (2020), the writing of "historical novel" began in the early 19th century, with W. Scott's work. He says that on the basis of the relationship between the novel and history, the phenomena of "time" and "space" are established through the same means of expression - language and writing - in both intellectual activities: "An attempt to reconstruct that time according to a system of knowledge, belief and values; There is a desire to make sense of a " moment" in history. A historical narrative emerges when past information is compiled and classified and transformed into a narrative established with some generalizations" (Türkeş, 2020: 1).

In this article, "The book Edirne Kırmızısı, written by Sabriye Cemboluk, was taken as the main text and, following the footsteps of the book, working life and labor relations in the textile industry in Europe, especially in the Ottoman Empire and England and France, were analyzed.

METHOD

Sabriye Cemboluk is a Turkish writer, playwright and journalist. He generally deals with migration issues in his novels and stories. He spent his childhood and early youth in Edirne (Edirne Municipality, 2021). It is thought that it is of particular importance that the novel of Edirne Kırmızısı was written by an author from Edirne.

The book was published by Ceren Publishing in 2021 as 374 pages and consists of 53 chapters. The main plot that makes up the book is as follows:

> *Gülnuş Sultan was Mehmed IV's favorite of Cretan origin, and a special dark and bright red reminded her of the poppies in Crete, and she wanted to cover her maternity room entirely with this red. When she did not like the color of any red produced in Edirne, her bridesmaid and a friend of hers secretly ordered the red they described to these dye houses run by the Romani people.*
>
> *With the ordered fabric, the first prince in 21 years arrives at the Ottoman palace on the same day. Thereupon, Sultan Mehmet IV (Avcı) said that this bright dark red color would symbolize Edirne and even the Ottoman Empire, and the sky and earth would turn red.*
>
> *Meanwhile, two spies and/or rivals one from England, one from France, and even one visitor from India are at play. The following events continue in this multicultural period of the city of Edirne, taking into the background the circumcision of the princes and the wedding ceremonies of the sultan's daughter in 1675.*

ANALYSIS

The fictional text, which forms the starting point of the paper, was analyzed with a qualitative approach. Qualitative research focuses on how events are given meaning (Tanyaş, 2014) and is defined as a process of creating meaning (Lyons and Coyle, 2007).

For the analysis, first of all, all kinds of texts (speech, description, etc.) related to working relations in the novel were determined and research "data" was created. In this process called 'descriptive analysis', "information" regarding the working relations in the text was revealed and classified in accordance with the aim of our study to draw a picture of the working relations of the period and geographies (Yıldırım and Şimşek, 2013).

RESULTS

The key themes and sample quotations that emerged as a result of the thematic classification are shown in Table 1.

Table 1. Edirne Red Labor Relations and Production-Management Process Themes

Theme Classifications	**Example Expression**	**Page Number**
Color and its emergence	*This color intoxicates the viewer. It seems like there are enchanted shapes wandering around inside.*	96
Influence of the palace	*It was obvious that there would not be enough dyers from Edirne to dye enough yarn and fabric to cover every corner of the vast empire. The sultan had already brought painters from Sofulu, Bursa and Izmir.*	104
International competition	*This color became the favorite of all kings and nobles, even the pope and cardinals, and the entire Christian world, from Europe to England and from there to America.*	146
Espionage	*If the unidentified spy learned the secret of red before them and reported it to his country, the British would have lost the battle for first place in the weaving that has been going on for years.*	217
Trade route	*Every time he looked at the river, the boats he watched moving, coming and going, made him realize the invisible trade artery of the city.... The port where they unloaded their cargoes and bought new cargoes in the future was the closest place that would bring him closer to the dyers' location. Some of the boats were carrying silk and fabrics brought to Edirne to be dyed. The dyed fabrics reached the Meriç River, then the sea, and went to Europe via the same route.*	120
Artisanal process	*This stone, added to the herbs and roots they use in dye, gives that bright miraculous color.*	213
Artisan	*They search and find their own colors, the grasses and roots from which they extract dye. They don't stop trying until they get the color they want. Thank God, Edirne's craftsmen are hard-working, curious and very skilled.*	42
Working conditions	*In the area close to the paint shops, painters returning home after finishing their night shift and people coming to work in the morning started to fill the streets.*	345
Living conditions	*Painters were also given houses and settled with their families close to the dyehouses.*	127

The most important content in the novel is the content related to the theme of "international competition": "... when the *wandering merchants in the city were presented with a roll of Edirne red silk fabric as a gift, their reign exceeded the borders of the Ottoman domain. For many years, merchants had been coming to the city because of this red color* (p: 109). In the entire text, 23 quotes were coded with this theme, and "espionage" as a sub-theme was included in 8 separate quotes: *"They received the order to die in a kidnapping incident but not to give your secret* (p: 133).

The emergence of the color, Edirne red; the sultan of the period, IV. Mehmed's “favorite” or Haseki Gülnuş’s a dream come true: “ *The red of the poppies blooming in the mountains and plains of Rethymno should now spread everywhere with silks, velvets and fabrics and bloom all over the world* ” (p: 370); Sultan’s dedicating the color to the city of Edirne upon the birth of his Prince, " *This color, born on the same day as our Prince, will be named after the beautiful city of Edirne (p: 67)"* can be considered as an intention to give this color a noble past (Türkeş, 2020).

In the book, descriptions are made that the weaving trade was by sea via the Tunca River and Meriç and that Rüstem Pasha Caravanserai was the accommodation place of all ambassadors, merchants and travelers: “(Rüstem Pasha Caravanserai) *was one of the indispensable inns of the Silk Road. Apart from merchants, travelers and some of the ambassadors sent by foreign states also stayed in this inn. ... Not everyone could enter the inner courtyard, where only rich merchants and ambassadors could stay. Those with permission would pass through the low curved door in the middle of the stone wall by bending over. The brave armed guards waiting on both sides of the gate did not let even a bird fly between the two courtyards. It was not that easy to reach the nobles, ambassadors and rich merchants who stayed in the inner courtyard. They traveled sometimes alone and sometimes with their families in closed luxury cars pulled by four horses, and lived like kings and queens in the mysterious atmosphere of Rüstem Pasha Inn. (p: 37).* “He *looked at the cargo boats moving on the Tunca River. "It was as if he was the owner of all the cargo on these boats that glided coyly from Meriç to the Mediterranean (p: 127)"*

In the novel, dyers are described as "craftsmen" and it is stated that they are predominantly Romani population and have a high work ethic: "*They search and find their own colors, the grasses and roots from which they extract dye. They don't stop trying until they get the color they want. Thank God, Edirne's craftsmen are both hard-working, curious and very skilled* (p: 42)” “… *He knew that it was necessary to work for at least five years to become a master painter. Not everyone could reach the level of mastery in painting, which was a delicate work. Those who were skilled were given very good money and opportunities by the order of the sultan. Arif's father also wanted to be a painter, but since that job was in the hands of gypsies, they could not hire his blond, blue-eyed father* (p:160)”.

In terms of Edirne Red production, from the collection of madder to the different stages of dyeing, there are descriptions in different parts of the text, sometimes similar to the telling of a fairy tale: “He held *the grass in his hands without hurting it, as if it were a very precious jewel, and watched it for a long time with admiration. He gently touched and lovingly caressed every leaf, stem, root, even the soil crumbs left on the roots. “He was as happy as if he had reunited with the unknown lover for whom he had spent the last ten years of his life* (p: 346).” “The *clothes that boiled with the stone turned red. This is how they discovered the painting business. Since then, these stones have been used in painting.* ” (p: 247). “On *the seventh day, he was in the process of changing the color of the mixture to Edirne red with a very special madder*” (p: 136).

The craftspeople’ life and the working conditions, which is the main subject of the article are not a very encouraging situation: “In one of the makeshift huts where the dyers live. (p: 43)*” If I tell poor people that there will be a bag of gold at the end of the work, they will embrace the work with all their heart* (p: 44). However, after obtaining the Edirne Red color, both working and living conditions changed greatly: “After *creating the magnificent color called Edirne Red with his brother, Boyacı Şaban's luck turned. He had received both the appreciation of Rabia Gülnuş Sultan and the rewards of the Sultan Effendi”* (p: 127). *From now on, they would be able to work in the paint shops given to them near Tunca and settle in houses with their families in nearby neighborhoods* (p: 103).

It is seen that in the novel, the Palace was the sole authority in all these improvements and in the management of both production and trade: “It was *said that the Sultan put all the dyers and weavers in the city under the command of the palace, and together they dyed the silk threads in a red that had never been seen in the world, and the weavers wove them day and night.”* (p: 83) “Our *Sultan allows Edirne red silk and fabrics to be used only in Ottoman domains. Never ever, there are no foreigners, no permission is given. An amount is given as a gift only to foreign ambassadors and important guests who are accepted into the palace. "The secret of this color is kept like a state secret"* (p: 104).

RESULTS AND DISCUSSION

Our study aimed to describe how the novel “Edirne Kırmızısı” creates a scheme regarding labor relations in the Edirne red dyeing process in the period and countries in which the novel is set, and thus the history of labor and work in this sector. Discussing the Edirne Kırmızı production process, which has close relations with the textile industry in England, which is the starting point of the industrial revolution, in this context is important for the history of labor and work in Turkey.

As a character of historical fiction and literary creativity, the historical records are quite different than the novel’s flow and content. However the main themes of it emerged a very good structure to analyze and interpret labor history of the period.

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USE OF *RUBIA TINCTORUM* L. IN COSMETIC PRODUCTS

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ABSTRACT

Rubia tinctorum has been used in textiles as well as cosmetic products since ancient times. For example, it was used as color cosmetics in ancient Egypt. Various organic compounds derived from plants have been identified in ancient cosmetic products by various analytical techniques. Pink or violet-pink materials have been found in Punic cosmetics dating to the second half of the 1st millennium BC. Archaeological contents of madder use have also been found in various Roman ungueenteria and cosmetic tools examined with various analytical techniques. Generally, a mordant is needed to use madder in pigment form.

Keywords: *Rubia tinctorum*, cosmetic products, toxicology, antroquinones

Rubia tinctorum, commonly known as dyer's root, is a plant species known for its red dye obtained from its roots. This plant has been used in the dyeing and cosmetic industry for centuries. Their uses in various cosmetic fields are summarized below:

Hair Dye: *Rubia tinctorum* is used as a natural hair dye, often when combined with henna. It is responsible for red and orange tones. These natural dyes, which generally have a low risk of allergic reactions, are a good alternative for people who are sensitive to chemical dyes.

Skin and Skin Products: Since dyer root has antioxidant and anti-inflammatory properties, it is used in various skin care products. However, more research is needed on its effect on the skin.

Cosmetic Colorant: *Rubia tinctorum* is also used as a natural colorant in cosmetic products. It can be used especially in products such as lipstick, blush and eye shadow (Figure 1).

Figure 1. Color cosmetic products prepared from *Rubia tinctorum* extract. Assoc. Dr. Gülşah Gedik, Trakya University Faculty of Pharmacy, Edirne, 2023.

When used to color soap or cosmetics, the root powder of *Rubia tinctorum* can create various shades of pink, purple and red, depending on concentration. Its CAS number is 84650-16-8 and its EC number is 283-497-9. However, it should be noted that the FDA requires cosmetic colorants specifically approved for use when coloring cosmetic products, and since madder is not approved as a cosmetic colorant, it is used in cosmetic products for its herbal properties and not for its natural coloring ability. Additionally, madder is not safe for baby products, so it is not used in baby products (www.soapquenn, 2023).

Madder has been used in textiles as well as cosmetic products since ancient times. For example, it was used as color cosmetics in ancient Egypt. Various organic compounds derived from plants have been identified in ancient cosmetic products by various analytical techniques (Wilner 1931; Forbes 1965; Scott 2016). Pink or violet-pink materials have been found in Punic cosmetics dating to the second half of the 1st millennium BC (Karmous et al., 1996; Huq et al., 2006). Archaeological contents of madder use have also been found in various Roman ungueenteria and cosmetic tools examined with various analytical techniques (Pérez-Arantegui et al., 2009, Bejarano Osorio et al., 2019). This pigment has been known since ancient times (Schweppe and Winter, 1997; Chenciner 2000; Daniels et al., 2014), and its role as a cosmetic product is reported in Greco-Roman texts (Wilner, 1931; Forbes, 1965). Generally, a mordant is needed to use madder in pigment form. It was used as a mordant in the analyzed archaeological pink cosmetics, probably an aluminum silicate (Marcaida et al., 2016) from pure white clay. With this, pink powders adhered to the surface of a Roman bronze cosmetic tool dated to the fifth century AD were prepared by precipitating madder on pure aluminum hydroxide (Pérez-Arantegui et al., 2009).

Besides the inorganic mordant, reddish madder has often been diluted with gypsum ($CaSO_4 \cdot 2H_2O$) or calcite ($CaCO_3$), a white component, for use in cosmetics (Figure 2) (Pérez-Arantegui, 2021).

Figure 2. Light pink powders found in a Roman spherical glass unguentarium dated to the mid-first century AD (Vitrix-Iulia-Celsa, Zaragoza, Spain) (Pérez-Arantegui, 2021).

Regarding the cosmetic use of *Rubia tinctorum*, caution should be exercised against allergic reactions. There is also a risk of Berber dermatitis, a phenomenon that can cause yellowish-brown staining of the skin, especially on light skin and sun-exposed areas. Therefore, it is usually a good idea to test it on a small area of skin before use.

Many genotoxicity studies have been conducted on madder and its components. In a study, alizarin and purpurin, among them, showed significant antigenotoxic activities on DNA damage caused by carcinogens in Drosophila (Takahashi et al., 2001). Ten years later, the carcinogenic effect of madder madder in rat kidney and liver was proven (Inoue et al., 2009). The LD50 dose of alizarin in birds is 316 mg/kg orally, the lethal dose of purpurin in mice is 500 mg/kg intraperitoneally, and rubiadin is considered an acute toxic agent in the H302 category (Archives of Environmental Contamination and Toxicology, 1983; Summary Tables of Biological Tests, 1952).

Therefore, consultation with a healthcare professional or poison control center is always recommended.

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DYEING OF SILK WITH BUCKTHORN USING DIFFERENT MORDANT TYPES

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ABSTRACT

Silk has been the most popular fiber type from past to present with its features such as brightness and softness. These fibers, which have low production but high added value, are considered within the luxury category of fibers. The buckthorn is evergreen or deciduous prickly shrubs. The yellow color has been obtained from the fruits of this plant throughout history. Traces of the buckthorn plant on the yellow colors of many Anatolian carpets woven in the 15th - 17th centuries have been found.

In this study, silk fabrics and buckthorn were dyed using two types of mordants, and the numerical values of the obtained colors were measured. Additionally, the effect of the commercially available fixator on color fastness was examined. In the study, two types of pre-mordants, metallic (Alum) and oil mordant (Turkey red oil), were used to treat the silk fabrics, followed by the dyeing process. The color values of the dyed fabrics, as well as the results of washing and perspiration fastness, were investigated.

Keywords: Natural Dyes, Mordants, Fixator, Lux Fiber

INTRODUCTION

The silk filament produced by Bombyx mori consists of two fibroin filaments enclosed within a binding layer of sericin. The silk filaments extracted from the cocoons are first reeling, woven, degumming and dyed (Freddi et al., 2003). Silk fibres have been a material that has attracted the attention of women especially throughout history due to its soft handle, shiny appearance and drapability. Silk is called the "Queen of Fibres" and is gaining increasing popularity worldwide. For this reason, silk fibres are considered as luxury fibres (Atav and Namirti, 2011).

Buckthorn (*Rhamnus petiolaris boiss*) is a thorny shrub or tree-shaped plant that can grow up to 3 meters tall. It grows between 1000 and 1300 meters high in mountainous, hilly, rocky places, sunny slopes, forest clearings, under or on the edges of sparse forests (Karadağ, 2007). Most of the species possess yellowish green flowers with four to five ovate-triangular sepals (Köseoğlu and Kolak, 2023). The buckthorn plant contains a large number of flavonoids. Flavonoids are particularly important compounds due to their medicinal properties, including antibacterial (Deveoglu et al., 2013). The fruits of buckthorn were widely used in yarn and fabric dyeing in ancient times due to the dyestuffs they contain. Fruits of buckthorn give a yellow color and have been used to dye textiles yellow (Kayabaşı, 1995).

Some studies on the dyeing with buckthorn are available in the literature. In a study by Deveoglu et al. (2013), silk fabric was pre-mordanted with alum and then dyed with buckthorn and/or walloon oak. It was observed that color strengths (K/S) increased with increasing dye concentration in dyeing with buckthorn only. In the study by Benli and Bahtiyari (2022), woolen fabrics were dyed with buckthorn using different mordants. Color values, fastness results and UV protection effects of the obtained dyes were evaluated. It was observed that the UV protection of fabrics dyed with buckthorn increased. At the same time, good results can be obtained in terms of color fastness values, UV protection properties, and coloration without using metal salt. Different colors were obtained by using different metal salts as mordanting agent.

Mordanting is a process that should be carried out in order to increase color yield and fastness in dyeing fabrics/yarns with natural dyestuffs. The mordanting process can be carried out by 3 different methods: pre-mordanting, mordanting during dyeing (meta-mordanting) and post-mordanting. At the same time, the mordant chemicals used can be obtained naturally or by chemical synthesis. The type of chemical used in mordanting has significant effects on color and fastness. For this reason, the choice of mordant is very important in order to achieve the desired color and at the same time to obtain the desired fastness values (Cristea and Vilarem, 2006; Prabhu and Bhute, 2012; Singh and Bharati, 2014).

Aluminum Potassium Sulfate (Alum) is the most widely used mordant in natural dyeing and this salt is also called alum ($KAl(SO_4)_2$) (Singh and Bharati, 2014; Degano et al., 2009). Turkish red oil (TRO) is an oil mordant and is often used in combination with alum (Singh and Bharati, 2014).

In this study, silk fabrics were pre-mordanted with alum or Turkish red oil and then dyed with buckthorn and the color values and fastness results of the samples were obtained. At the same time, the effects of commercially purchased fixer on the fastness values of dyed fabrics were investigated.

MATERIAL AND METHOD

Material

In the study, 100% silk fabrics woven in the plain construction were used. The silk fabric was supplied from Büyükaşıklar Silk Company. The weight of the silk is 80 g/m^2, and the weft density of the fabric is 42, while the warp density is 61. The CIE LAB color coordinates of the raw white fabric were measured as L* = 94.7, a* = -0.44, b* = 2.41, with berger whiteness value of 66.4.

Alum, fixator and buckthorn used in the study was purchased from Naturaldyes Company. Turkish red oil (TRO) was purchased from Ataman Chemicals Company.

Method

In order to make the silk fabric ready for dyeing, sericin was removed. This process was carried out at 80°C for 60 minutes in a soap solution without bleach (5 g/L). The samples were then rinsed in cold water and hung to dry. The fabrics were pre-mordanted in the first stage. Alum or TRO were used as pre-mordanting chemicals. The mordanting process was carried out by using 7% alum ($KAl(SO_4)_2 \bullet 12H_2O$) or TRO with demineralized water at 80 °C for 1 hour.

After pre-mordanting, the dyeing process was started. In the dyeing process, only dyestuff and fabric were added to the bath so that the bath ratio was 1/70. The amount of dye was adjusted as 100% according to the fabric weight. The dyeing process was carried out at 80 °C for 1 hour. After the fabrics were dyed, two samples were post-treated with fixator (5 g/L). This process was carried out for 10 minutes and at room temparature. All samples were then washed and rinsed with bleach-free soap at 40 °C for 30 minutes.

The numerical values of the colors of the dyed fabrics were measured with the X-Rite Ci 6x spectrophotometer device. As a result of the measurements, the color's CIE L*, a*, b* values were obtained. The strength of the color (K/S) was calculated from the measured %R and the formula is as follows.

$$K/S=\frac{(1-R)^2}{R^2} \quad (1)$$

In this equation, K represents the absorption coefficient of color, S represents the scattering coefficient of color. %R corresponds to the reflectance (reflection) value of the sample at maximum absorbance. The higher the K/S value, the darker the color becomes. (Yılmaz Şahinbaşkan, et al., 2018).

Washing, perspiration and rubbing fastnesses were applied to dyed fabrics. Washing fastness were conducted on the Gayrowash washing test device (TS- EN-ISO105 C06, 2010). Rubbing fastnesses were also carried out dry and wet with a crockmeter.

RESULTS AND DISCUSSION

Color Values

Values of the colors are given in Table 1. When the obtained colors are compared, it is observed that the fabric colors pre-mordanted with alum are darker. The a* and b* values of dyed samples indicate that all the samples were found in the yellow zone (Figure 1). At the same time, it can be seen that the b* value, which is a measure of yellowness, is higher in fabrics dyed with alum (Sample no 2 and 4) compared to TRO (Table 1 and Figure 1). Figure 2 shows that the color strength (K/S) values were higher in fabrics pre-mordanted with alum.

The main function of the oil mordant is to form a complex with alum, which is used as the main mordant (Singh ve Bharati, 2014). Since TRO as an oil mordant is an auxiliary mordanting agent and alum is the main mordanting chemical, it can be concluded that the colors of the fabrics pre-mordanted with alum are darker.

When the effect of fixator on color was examined, it was observed that the L* values of the fabrics post-treated with fixator increased. This leads to the conclusion that the colors are lighter. At the same time, when we look at the b* values, it was observed that the use of fixator decreased the yellowness. In general, we can interpret that the use of fixator lightens the color.

Table 1. CIE L*a*b* values of samples

Sample No/Sample Type	L*	a*	b*	Dyed fabric
1 / Buckthorn-TRO (without fix)	65.67	7.29	53.66	
2 / Buckthorn-Alum (without fix)	58.80	10.05	63.64	
3 / Buckthorn-TRO (with fix)	69.94	3.38	44.24	
4 / Buckthorn-Alum (with fix)	63.62	8.05	56.43	

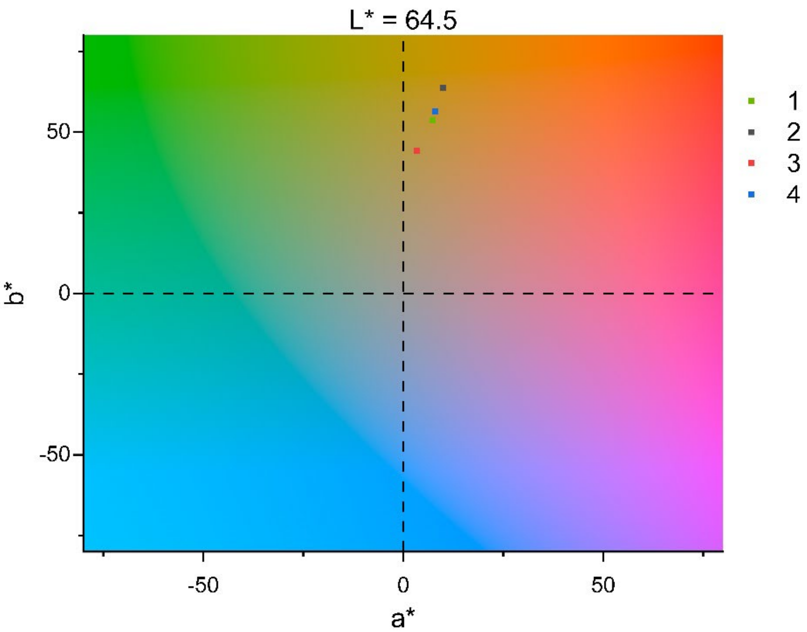

Figure 1. The CIE-LAB color graph drawn based on the a* and b* color values of the samples

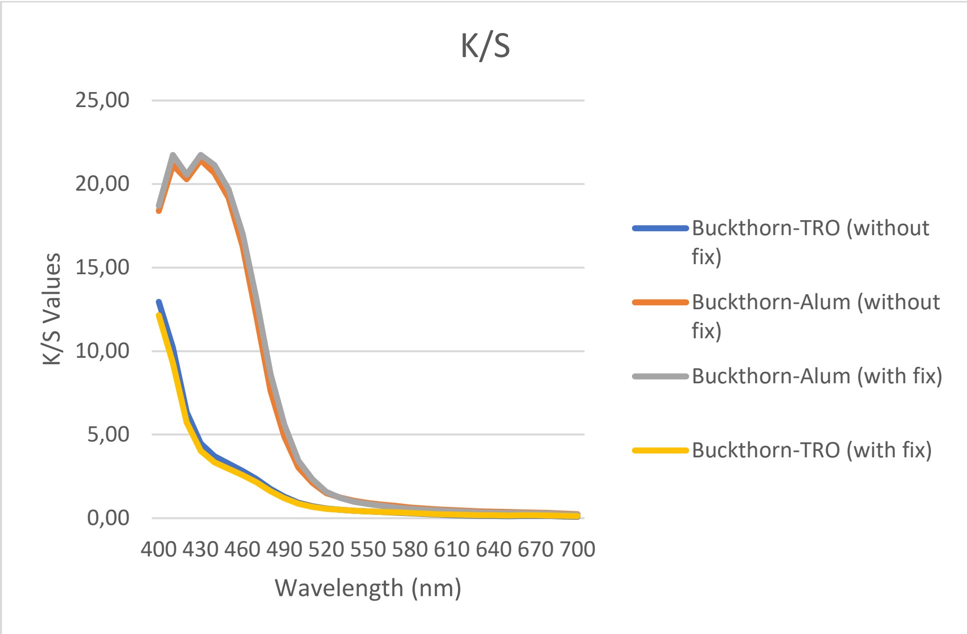

Figure 2. K/S graph of samples

Fastness Results

Washing, rubbing and perspiration fastness values are given in Table 2. It was observed that there was an improvement in the rubbing fastness of only alum pre-mordanted fabrics when treated with fixator. However, it was observed that the perspiration fastness of the same fabrics was worse when treated with fixator. In TRO-treated fabrics, the use of fixator had an effect only on the alkali perspiration fastness but decreased the washing fastness. Since there was no improvement in fastness at the end of the study, it is recommended that the process should be changed and tested.

Table 2. Fastness values of the samples

Sample no	Washing fastness	Acidic perspiration fastness	Alkaline perspiration fastness	Rubbing fastness	
				Wet	Dry
1	4	3/4	3	4/5	4/5
2	4/5	3/4	3/4	3/4	3/4
3	3/4	3/4	4	4/5	4/5
4	4/5	3	3	4	4/5

CONCLUSION

Buckthorn plant is a type of plant used especially in the past to dye textile products in yellow color. In this study, buckthorn was used to obtain yellow color in silk fabrics. In dyeing, alum was used as metallic mordant and TRO was used as oil mordant. After dyeing, two samples were treated with fixator to see the effect of fixator while the other two were not post-treated.

According to the results obtained, it was observed that the color of silk fabrics pre-mordanted with alum was more yellow and darker than those pre-mordanted with TRO. It was also observed that post-treatment with fixator lightened the color slightly. It was observed that the use of fixator did not improve washing, perspiration and rubbing fastnesses.

As a result of this study, it is recommended that the amount of fixator usage and process should be changed and analyzed in future studies.

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PLANT BASED NATURAL DYES AND WOOL YARN APPLICATIONS

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ABSTRACT

Plant based natural dyeing is a dyeing process obtained from the dyes of various plants. These dyestuffs are generally obtained from different structures of plants such as roots, stems, leaves, flowers, branches, underground shoots. Natural dyeing is the process of applying recipes that have been used traditionally from past to present within the framework of certain methods. As one of the richest regions in the world in terms of plant diversity, natural dyestuffs have been produced in many regions of Anatolia for centuries and have been used especially in the textile field. These dyestuffs are also of great importance in the weaving culture, which is among the traditional handicrafts. Especially in recent years, with the return to nature, herbal natural dyes and natural dyeing have come to the fore. In this context, dyeing applications with traditional methods and recipes using various herbal dyes are aimed. In this study, applications were made to 100% wool yarns using Daisy *(Anthemis chia)* and Madder / Root Dye (*Rubia tinctorum* L.*)* In herbal dyeing, natural dyeing processes and processes are presented.

Keywords: Natural dyestuff, Wool yarn, Plant coloring.

INTRODUCTION

Mankind's use of colored substances in nature to obtain dyestuffs dates back thousands of years. Natural dyeing is a dyeing process made by using dyes found in various plants and insects. The use of dyestuffs in plants dates back to the Bronze Age (Dölen, 1992). Herbal natural dyeing is a dyeing process obtained from the dyes of various plants. These dyestuffs are generally obtained from different structures of plants, such as roots, trunks, leaves, flowers, branches, underground shoots, roots, seeds and seeds. Dyeing is performed with the prepared extracts using various techniques (Şanlı, 2011). It is thought that dyestuffs originally extracted from colored flowers with water were transferred to the fiber. However, it has been discovered that such direct (substantive) dyestuffs are not resistant to washing and sunlight, and it is predicted that mordant dyeing occurred by chance (Dölen, 1992).

Natural dyeing is the process of applying recipes that have been used traditionally from past to present within the framework of certain methods. In many regions of Anatolia, which is shown as one of the richest regions in the world in terms of plant diversity, natural dyes have been produced for centuries and used in many areas such as medical treatment, and many applications have been made, especially in the field of textiles (Tüm Cebeci, 2020). Collection of material and time of collection is an important issue because; the quality of dyestuffs reaches its highest level as the plants mature. At the same time, ecological conditions (heat, humidity, soil, rainfall) significantly affect the amount of dyestuff to be obtained (Arlı, Kayabaşı, Ilgaz, 1993). During the Ottoman period, cities such as Bursa, Edirne, Istanbul, Tokat, Kayseri and Konya were among the centers where the dyeing craft was highly developed. At the same time, dyeing and cultivation of special dye plants were carried out in many regions of Anatolia (Arlı, 1984).

In this research, herbal natural dyeing, which dates back to ancient times and has been practiced but is not practiced as frequently as it used to be due to the increasing use of synthetic dyes, was examined. Because in recent years, with the return to nature, herbal natural dyes and natural dyeing have come to the fore. In this context, dyeing applications with traditional methods and recipes using various herbal dyes are aimed. In this study, for orange color dyestuff; Daisy *(Anthemis chia)* and Madder / Root Dye *(Rubia tinctorum* L.) was used for the red color. The aim was to apply red color tones and accordingly color 100% wool yarns according to traditional recipes.

MATERIAL AND METHOD

Material

Application studies were carried out with 100% natural wool yarn, mordant materials, auxiliary materials and vegetable dyestuffs. The dyestuff used is; Daisy *(Anthemis chia),* Madder / Root Dye *(Rubia tinctorum* L.).

Method

Mordanting process of 100% natural wool yarns, preparation of dye extracts, and mordant dyeing method were used. 100% natural wool yarns, mordant material, herbal dyes and application processes used in the research were carried out in the Natural Dyeing Laboratory of Marmara University Faculty of Fine Arts, Department of Traditional Turkish Arts.

APPLIED DYEING METHODS

Mordant Dyeing

The majority of natural dyes consist of mordant dyes. Such dyestuffs cannot bond with the fiber directly and spontaneously through chemical bonds. For this, an intermediary substance is needed to ensure and strengthen the bonding of dyestuffs and fibers. Such substances are called "mordant" (Enez, 1987). Mordant has a binding function between textile fiber and dyestuffs. The substances used for this purpose are called mordant substances. In the historical process of the mordanting process, approximately B.C. It was seen to have emerged in India around 2000. B.C. Around 3000 BC, the Sumerians obtained alum and iron sulphate in pure form. Therefore, alum was used as one of the first chemical compounds known and obtained in pure form. In the Anatolian region, alum, B.C. It was produced by the Hittites around 2000 BC (Dölen, 1992). Alum, one of the most commonly used mordant substances, was also used in the application study (Table 1).

NATURAL DYES USED IN APPLICATION

Daisy *(Anthemis Chia)* and Madder (*Rubia tinctorum* L.)

To obtain the orange color, first yellow color dyeing is done and then madder is added to the same dye bath to create orange color. Depending on the amount of madder, a light or dark shade of orange can be obtained. While painting, work is carried out first with the daisy plant and then with the madder plant. The mordant dyeing process and application of Daisy and madder plants and wool yarn are presented in (Table 2).

Madder (*Rubia tinctorum* L.)

It is the most widely used herbal dye in Turkey (Dölen, 1992). It is a 1-2 meter tall plant that grows in fertile soil. Turkey has been seen as the homeland of Madder. In the 1700s, Turkey provided two-thirds of the world's madder needs (Eşberk and Köşker, 1945). At the same time, the color obtained with Madder *(Rubia Tinctorum)* has become famous and known as Turkish Red or Edirne Red in the history of dyeing (Genç, 2014). In international literature, it is called Turkish Red, English (Turkish Red), French (Rouge de Turc) and Edirne Red (Rouge de d'Andrinople) in Europe. It has been seen as a historical color in France, where awards were given to those who solved the secret of the dyeing method (Gönenç Güler, 2020).

When madder was examined, it was determined that the dyestuffs were found in the root of the plant. In the dyeing analysis results made with Rubia tinctorum, it was determined that there were nine different dyestuffs, and the leading one of these dyestuffs was alizarin. The name “Alizarin” includes the Arabic suffix “al” (Enez, 1987). The amount of dyestuff (Alizarin) may vary depending on the geographical conditions in which the plant is grown (Karadağ, 1997). A wide variety of dyeing methods can be done with madder. The red color obtained depending on the substances added to the mordanting and dye bath shows a very wide range of color tones. For example, in a madder dyeing process with alum mordant, Yellowish Red is obtained, while with iron mordant, Brown Red is obtained. This dyestuff has also been used in medical treatments; For example, it has been seen in written sources as a treatment for diuretic, birth aid, vitamin C deficiency (Enez, 1987). In the dyeing process, dried and ground roots of the plant and mordant dyeing are used (Karadağ, 2007). Three different applications and processes of madder plant and wool yarn with mordant dyeing are presented in (Tables 3, 4, 5).

RESULTS

Dyeing Recipes and Application Procedures

Table 1. Mordanted wool yarn

Mordanting	Process
	20% alum based on the weight of the yarn is weighed on a precision scale and added to the mordanting bath. After the dissolution process, yarn is added. It is brought to boiling point. It is kept at 100 ^{0}C for 1 hour. The yarn is left to cool in the bath, then taken out of the bath and dried.

Table 2. Wool yarn dyeing process with daisy *(A. chia*) and madder (*R. tinctorum* L.)

Sample Painting	Dye plant	Ingredients	Painting color	Dyeing method	Dyeing temp.	Painting time
	Daisy (*A. chia*) and Madder (*R.tinctoru m* L.)	Quercetin, Lutechin, Opryenin.	Orange	Mordant dyeing	100 ^{0}C	5 minutes
Process	The wool yarn is heated in a dyeing bath containing 50% of its weight of daisy and sufficient water. After boiling, wool threads are added, waited for 30 minutes, then removed, 3% madder is added and boiled for 5 minutes, then washed, rinsed and dried in the open air.					

Table 3. 1st Dyeing process of wool yarn with the root dye (*R. tinctorum* L.) plant

Sample Painting	Dye plant	Ingredients	Painting color	Dyeing method	Dyeing temperat ure	Painting time
	Madder (*Rubia tinctorum* L.) 1. Painting	Alizarin, Purpurin, Pseudopur purin, Munjistin, Rubiadin.	Red	Mordant dyeing (15% alum and 5% cream of tartar)	85 ^{0}C	30 minutes
Process	(15% alum and 5% cream of tartar) is boiled for 1 hour and the wool yarn is mordanted for a day, and 100% of the madder and wool yarn of the 20% mordanted wool yarn are added simultaneously to the dyeing bath at room temperature and slowly heated. When the temperature reaches 85 ^{0}C, heating is stopped and left to cool in the dyeing bath for approximately 30 minutes. After cooling, the wool threads are taken, washed, rinsed and left to dry in the shade. "Turkish Red" and "Edirne Red" colors are produced on old carpets. Dyeing water is reused for the 2nd or 3rd dyeing.					

Table 4. 2nd Dyeing process of wool yarn with the Root Dye (*R. tinctorum* L.) plant.

Sample Painting	Dye plant	Ingredients	Painting color	Dyeing method	Dyeing temperatu re	Painting time
	Madder (*R.tinctor um* L.) 2. Painting	Alizarin, Purpurin, Pseudopur purin, Munjistin, Rubiadin.	Red	Mordant dyeing (15% alum and 5% cream of tartar)	85 ^{0}C	30 minutes
Process	1. Add the same amount of wool yarn to the dyeing bath in which the red color has been obtained by dyeing and start heating it. After it starts to boil, it is kept at 85 ^{0}C for 30 minutes. Then it is washed, rinsed and dried in the shade.					

Table 5. 3rd Dyeing process of wool yarn with the root dye (*R. tinctorum* L.) plant

Sample Painting	Dye plant	Ingredients	Painting color	Dyeing method	Dyeing temperatu re	Painting time
	Madder (*Rubia tinctorum* L.) 3. Painting	Alizarin, Purpurin, Pseudopur purin, Munjistin, Rubiadin.	Red	Mordant dyeing (15% alum and 5% cream of tartar)	85 ^{0}C	30 minutes
Process	2. Add the same amount of wool yarn to the dyeing bath in which the red color was obtained by dyeing and start heating it. After it starts to boil, it is kept at 85 ^{0}C for 30 minutes. Then it is washed, rinsed and dried in the shade.					

CONCLUSION

In the research, herbal natural dyeing, which dates back to ancient times and has been applied but cannot be applied as frequently as it used to be due to the increasing use of synthetic dyes, was examined. Dyeing applications were carried out using traditional methods and recipes using various herbal dyes.

Applications have been made to woolen threads, which have an important place in traditional Turkish handicrafts and culture and are the main materials in weavings. Herbal dyes that give yellow and red colors were chosen.

In this direction, it is aimed to color wool yarns according to traditional dyeing techniques. Mordant dyeing studies, one of the methods used in natural dyeing, were carried out. The dyestuffs used are; for orange color dye; Daisy *(Anthemis chia)* and

Madder *(Rubia tinctorum* L.), red color dyes are used as Madder *(Rubia tinctorum* L.). In madder *(Rubia tinctorum* L.), red colors in different tones were obtained with 3 separate applications in the same dye bath. As a result of all these practices, it has been seen that dyestuffs, dyeing recipes and methods are very important for cultural heritage in terms of preserving dyeing recipes and methods, ensuring sustainability and transferring them to the future in order to continue traditional methods and practices. It is important to provide empowerment environments.

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INVESTIGATION OF COLOR FASTNESS PROPERTIES OF EDİRNE RED DYED FABRICS AGAINST PERSPIRATION

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ABSTRACT

Natural dyes obtained from plants, insects, animals and minerals are renewable and sustainable bioresource products with minimal environmental impact and have been known to be used since ancient times, especially in coloring textiles. The industrialization of textile production has led to the development of synthetic dyes as alternatives to popular natural dyes. Nowadays, with increasing awareness of eco-safety and health issues, environmentally harmless and non-toxic natural dyestuffs are gaining popularity again. One of the difficulties in the industrial use of natural dye products is that their performance is thought to be poorer than synthetic dyes in terms of fastness properties. In the study, red color pigment in powder form obtained from *Rubia Tinctorum* L. plant roots was used as natural dye. An extract was prepared from red color pigment. The dyeing process was done using the pre-mordanting technique. Dyeing recipes were prepared using chemicals such as ethyl alcohol, Edirne red oil and alum. Sweat fastness values of silk fabrics dyed in Edirne Red color with different dyeing recipes prepared were measured according to international standards. With the data obtained, it has been determined that the sweat fastness values of silk fabrics dyed with *Rubia tinctorum* L. Plant in Edirne Red color have the values expected from textile products. It has been observed that dyeing auxiliaries such as alcohol, Edirne red oil and alum used in dyeing have an effect on sweat fastness.

Keywords: Silk, Textile, Natural Ddye, Rubia Tinctorum, Fastness

INTRODUCTION

Textile dyestuff is an organic molecule that can be dissolved or rendered soluble in water to give color to a particular textile product, and can be obtained from natural or synthetic sources. Natural dyes are produced from plants, animals, and minerals (Mahapatra, 2016), while synthetic dyes are produced from synthetic sources such as petroleum byproducts and soil minerals.

Recently, increased awareness of environmental problems and chemical pollution has increased the demand for textile products colored with natural dyestuffs, which have better biodegradability and higher environmental compatibility (Ali and El-Mohamedy, 2011).

In order for natural dyes to be included in the dyeing industry, the following studies must first be carried out;

-adaptation of traditional processes to current technology (Ferreira et al., 2004).

-providing the appropriate amount of dye plant material to dye shops (Bechtold et al., 2007).

-Selection of materials leading to products with acceptable fastness properties (Mussak et al., 2009)

Rubia tinctorum L. also known as madder madder (Blackburn, 2017), is one of the oldest and most popular red dyes found in nature.

Although the main coloring pigments of *R. tinctorum* L. roots are alizarin (1,2-dihydroxy-anthraquinone) and purpurin (1,2,4-trihydroxy-anthraquinone), other anthraquinones such as pseudopurpurin, xanthopurpurin, rubiadin and munjistin are also present mostly in glycoside forms (Karadağ et al., 2014).

Very few natural dyes can bind directly to the fibre. Generally, in dyeing with natural dyestuffs, auxiliary substances are needed that bind them to the fibers and increase their resistance to the effects they encounter such as water, sun, friction and chemicals. These excipients are called mordants. The function of mordant is to form water-insoluble complexes by binding dyestuffs and fibers with mechanical or chemical bonds. During the dyeing process, water-soluble natural dyestuffs are bound to the fibers with mordant and become insoluble or barely soluble in water (Saxena and Raja, 2014).

In colored textile products, color and fastness do not depend only on the dyestuff; the concentration and type of mordant are also effective. In the dyeing process with *Rubia tinctorum* L., which is one of the natural dyes in the group of mordant dyes, it is necessary to pre-treat the textile materials with mordant solution. The metal salt most commonly used as a mordant is alum (Derksen and Van Beek, 2002).

One of the difficulties in the industrial use of natural dye products is that their performance is thought to be poorer than synthetic dyes in terms of fastness properties. The aim of this study is to investigate the color resistance to sweat of silk fabrics colored using the *R. tinctorum* L. plant. For this purpose, the sweat fastness of silk fabrics dyed in Edirne Red color with different recipes was examined. With the data obtained, the effect of chemical substances such as alcohol, Edirne red oil and alum used in dyeing recipes on sweat fastness was revealed.

MATERYAL VE METOD

Material

Red color pigment extracted from *Rubia Tinctorum* L. plant roots was used as natural dye. *R. tinctorum* roots were grown and collected at Trakya University Havsa Vocational School in Edirne.

Alum: Obtained from Natural Dyes Company. It was used as a mordant in dyeings.

Ethanol: Obtained from Merck. It was used as a dye solvent.

Turkish red oil: Commercially available. It is vegetable oil.

100% silk fabric, ready for dyeing, was purchased from Büyükaşıklar Company. The silk fabric has a width of 140 cm and a weight of 75 g/m^2. Before use, the fabric is washed with a solution containing 5 g L -1 non-ionic soap powder for 10 minutes at 30 °C, and the fabric is thoroughly rinsed with water was rinsed and dried at room temperature.

Method

Preparation of Rubia tinctorum Roots for Dyeing

The material used in dyeing is the roots. Harvesting is done by removing plants that are 2-3 years old from the soil. The roots of the removed plants are first cleaned of their soil and then washed with water. The roots are chopped into 4-5 cm sized pieces and left to dry in a shaded place. After waiting for 1 week in the open air, it is dried in the drying oven at 60-65 ºC for 24 hours. The roots are ground into powder with the help of a grinder and packaged to prevent moisture.

Figure1. Shoot roots Figure 2. Powder Roots

Dye Extract Preparation

An extract was prepared from the roots of *Rubia tinctorum* L. plant for dyeing process.

Powder dye obtained from *Rubia tinctorum* L. roots: 30 g.

Water: 1000 ml

Temperature: 80 ºC

Time: 60 min.

The solution was then cooled and filtered. Prepared dye extract 1000 ml. Completed. The obtained extract solution was used as stock solution in sample silk fabric dyeing.

Dyeing

In the dyeing process, the pre-mordanting technique, which is one of the dyeing methods for natural dyes, was used. Silk fabric samples to be dyed were treated with 7% alum based on fabric weight at 80 °C for 60 minutes pre-mordanting was done. The extract prepared from powdered *Rubia Tinctorum* L. plant roots at a concentration of 30 g/L was used in the dyeing processes.

Different recipes have been prepared using chemicals such as ethyl alcohol, Edirne red oil and alum as mordant. Prepared dyeing recipes and sample codes are in Table 1.

Table1. Dyeing Recipes and Sample Codes

Sample Codes	Dyeing Recipes
B1	Dyeing with 100 ml extract at 80 ^{O}C for 60 minutes.
B2	Dyeing with 100 ml extract + 0.1 g alum at 80 ^{O}C for 60 minutes.
B3	Dyeing with 100 ml extract + 0.1 ml Turkish Red Oil at 80 ^{O}C for 60 minutes.
B4	Dyeing with 100 ml extract + 0.1 g. Alum + 0.1 ml Turkish Red Oil at 80 ^{o}C for 60 minutes.
B5	Dyeing with 150 ml extract at 80 ^{O}C for 60 minutes.
B6	Dyeing with 150 ml extract + 0.1 g alum at 80 ^{O}C for 60 minutes.
B7	Dyeing with 150 ml extract + 0.1 ml Turkish Red Oil at 80 OC for 60 minutes.
B8	Dyeing with 150 ml extract + 0.1 g. Alum + 0.1 ml Turkish Red Oil at 80^{o}C for 60 minutes.
B9	Dyeing with 100 ml extract + 20% ethanol at 80^{o}C for 60 minutes.
B10	100 ml extract + 20% ethanol + 0.1 g. Dyeing with alum at 80 ^{o}C for 60 minutes.
B11	Dyeing with 100 ml extract + 20% ethanol + 0.1 ml Turkish Red Oil at 80 oC for 60 minutes.
B12	Dyeing with 100 ml extract + 20% ethanol + 0.1 g. Alum + 0.1 ml Turkish Red Oil at 80 ^{o}C for 60 minutes.

Dyeing of sample silk fabrics was done on Ataç lab-dye HT brand-model, steel tube, and programmable dyeing machine.

The same washing process was applied in all dyeing processes. The silk fabric removed from the dye bath is rinsed with cold water, washed with 3% soap solution at 1.30 liquor ratio at 40-45 °C, rinsed, squeezed and dried at room temperature. The soap does not contain bleach.

Color Measurement

Color measurements of dyed silk fabric samples were made by determining L *, a * and b * values. The measurement was done with an X-RITE brand color spectrophotometer in accordance with TS EN ISO 105-J03, 2010 standard, with a 10-degree viewing angle at D65 daylight source.

Perspiration Fastness Test

It is to check whether the colors of the printed-dyed cloths that will be in contact with the human body as clothing are resistant to the effects of perspiration. The test is carried out according to TS EN ISO 105-E04 standard. The sample is treated with alkaline and acidic solutions for 30 minutes.

RESULTS AND DISCUSSION

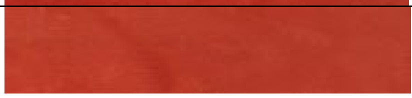
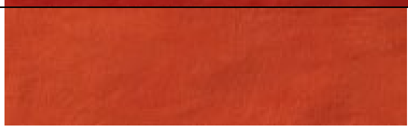
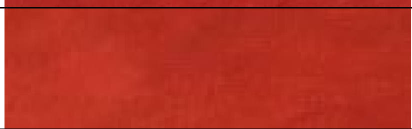
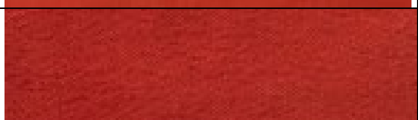
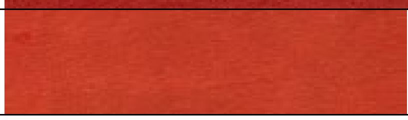
Color Values

Color measurement values are given in Table 2. When the L* values given in Table 2.are interpreted; It has been observed that the lightness value (L*) of Edirne Red color on silk fabric varies depending on the amount of extract and the type of chemical substance used in the dyeing bath. Among all dyed silk fabric samples, the lightest Edirne Red color tone was obtained with 100 ml extract + 0.1 g. Alum + 0.1 ml Edirne Red Oil at 80ºC for 60 minutes, the darkest color tone was obtained in the silk fabric sample dyed with 150 ml of extract at 80 ºC for 60 minutes. It has been observed that using Turkish red oil and alum together in the dyeing bath causes the color tone to lighten. It was observed that the color tone darkened with 150ml of extract.

The results regarding the L values obtained are compatible with previous studies (Belino et al., 2021), staining with *R. tinctorum*. They reported that the L* value tended to be lower in dyeings performed with higher extract concentration values. It was found that the L* value of the samples dyed by mordanting was higher than that observed in the unmordanted section.

This fastness values were found to be similar to previous studies. Aydın (2001) dyed silk fabric samples with herbal natural dyes and measured the perspiration fastness values. In the study results; fastness values; it was between 3-4 in the fabrics dyed with green walnut shells and 1-4 in the samples dyed with madder.

Table 2. Color Values

Sample code	Silk fabric	Color Values		
		L	a	b
B1		43.79	37.55	25.78
B2		46.57	34.82	26.77
B3		43.62	38.30	28.93
B4		48.55	33.69	26.52
B5		38.02	38.41	28.46
B6		40.62	36.60	27.30
B7		38.57	38.37	28.17
B8		49.43	32.12	31.50
B9		40.82	38.04	25.08
B10		42,69	35.33	27.78
B11		39,31	39.03	26.33
B12		47.89	33.94	29.78

As environmental issues began to gain importance in textiles, some legal restrictions on this issue were also created. Some decisions of the European

Community on this issue are as follows. According to Decision 76/ 464/ EEC; Color and stain fastness to sweat should not be lower than 3-4. It has been shown that depending on the mordant used and the dyeing recipe, sweat fastness values in compliance with environmental legislation can be achieved in silk fabrics dyed in Edirne Red color.

Perspiration Fastness Data

In this study perspiration fastness values were between 2-4 (Table 3).

Table 3. Perspiration Fastness Data

	Multifiber fabric sections					
Samples	Wool	Acrylic	Polyester	Polyamide	Cotton	Acetate
1.1	2	3	3	2	3	3
1.2	2	3	3	2	3	3
1.3	2	3	3	2	3	3
1.4	2	3	3	2	3	3
2.1	3	3	3	3	4	3
2.2	3	3	3	3	4	3
2.3	3	3	3	3	4	3
2.4	3	3	3	3	3	3
3.1	3	4	4	3	4	4
3.2	3	4	4	3	4	4
3.3	3	4	4	3	4	4
3.4	3	4	4	3	4	4

CONCLUSION

It has been determined that sweat fastness values vary between 2-4. It has been observed that the degree of fastness varies depending on the auxiliary substances in the dyeing recipe. It has been determined that adding alcohol to the dyeing recipe improves sweat fastness values. It is thought that this is the result of improving the solubility of madder with alcohol, thus increasing its binding to the fabric.

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DETECTION OF COLOR DIFFERENCES IN WOOL YARNS DYED WITH NATURAL DYE WITH HANDHELD SPECTROPHOTOMETER

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ABSTRACT

Today, instead of the dye types that can be produced in many different types and numbers, they can be obtained from natural sources, such as plants, mushrooms, barks, roots, insects and other natural sources. Dyeing of textile products can be done in the form of fibre, rope and fabric. Dyeing is important for the consumer in terms of both production quality and color differences. Color harmony must be achieved, especially in products containing several different colors.

Color differences between different yarns are among the inevitable consequences of dyeing. When environmental conditions affecting the dyeing environment combine with the conditions affecting dyeing, the same dyeing may not be achieved each time. For this reason, in this study, the differences between wool yarns dyed with natural dyes were determined using a hand spectrophotometer in order to obtain the closest dyeing and determine the resulting fabric.

In this study, wool yarns supplied from the market were dyed with tetra leaves in various ways with and without mordant, and the color differences on these dyed yarns were tried to be determined and compared. In this way, efforts were made to introduce new colors to the range of colors that can be obtained with natural dyes.

Keywords: Wool yarn, Color Differences, Hand Spectrophotometer

INTRODUCTION

Today, dye types that can be produced in many different types and numbers can be obtained from natural sources, such as plants, mushrooms, barks, roots, insects and other natural sources. Dyeing of textile products can be done in the form of fibre, rope and fabric. Dyeing is important for the consumer in terms of both production quality and color differences. Color harmony must be achieved, especially in products containing several different colors.

The use of natural dyes not only demonstrates an environmentally friendly approach but also ensures that colors occur naturally and organically. Efforts are being made to increase the color range by expanding natural dye sources. Because; Natural dyes have their own unique tones and appearance.

In Özdemir (2021) study; He investigated the usability of Anthocyanin (Cyanidin) dye, which was found in the seed shell of peanuts, in natural dyeing. Natural dyeing of wool skein yarns was carried out using alum mordant. By determining the spectrophotometric color values of the dyed samples, colors generally in brown tones were obtained from the peanut shell, and as a result of the fastness tests, values above the acceptable limits for use were reached. In the study of Arık et al. (2011); the effect of pre-treated with chitosan biopolymer on the functional and aesthetic properties of woolen fabrics to be naturally dyed with *Reseda luteola* (Love Flower), which grows widely in Mediterranean countries, was investigated. It has been observed that chitosan significantly increases both the antibacterial activities and color yield of woolen fabrics. In Yılmaz (2020) study; the golden grass was ground with the help of a grinder before being used in the dyeing process, and the liquor ratio was selected as 1:70 in the dyeing process. He also carried out dyeing experiments using plant sources in the ratio of 1:1 and 1:3 in proportion to the fabric weight. After the dyeing process, it was subjected to the main washing process at 70 ^{0}C. After drying at room temperature, color values were determined with the help of a spectrophotometer, and brown and yellow tones were obtained on woolen fabrics by using golden grass and different mordant substances.

Color differences between different yarns are among the inevitable consequences of dyeing. When environmental conditions affecting the dyeing environment combine with the conditions affecting dyeing, the same dyeing may not be achieved each time. For this reason, in this study, the differences between wool yarns dyed with natural dyes were determined using a hand spectrophotometer in order to obtain the closest dyeing and determine the resulting fabric. In Yilmaz (2020) study; the golden grass was ground with the help of a grinder before being used in the dyeing process, and the liquor ratio was selected as 1:70 in the dyeing process. He also carried out dyeing experiments using plant sources in the ratio of 1:1 and 1:3 in proportion to the fabric weight. After the dyeing process, it was subjected to the main washing process at 70 ^{0}C. After drying at room temperature, color values were determined with the help of a spectrophotometer, and brown and yellow tones were obtained on woolen fabrics by using golden grass and different mordant substances. In Aras et al.'s (2019) study; in this context, natural dyes that are non-toxic and can be obtained easily and safely are a good alternative to synthetic dyes. By comparing the strength, color fastness, washing fastness and rubbing fastness values of naturally dyed cotton products with the same synthetic dyed cotton products, their effects on the fabric were examined. In Tutak and Benli (2008) studies; Natural dyes obtained from some fruits and plants were dyed wool fibers in different shades with five different natural dyes and three different mordant substances. After dyeing, color measurements and fastness studies were carried out. These natural dyes can be easily used on wool fabric in terms of the colors obtained and their fastness to washing, rubbing, sweat and light. In their study by Tutak, Acar and Akman (2014); Pomegranate peel dye solution was prepared and used in woolen fabric dyeing. The effects of mordant type, concentration and chemical post-treatment on color and fastness were examined, and the fabrics had color yield between 6.63-23.05 and medium/high color fastness values. It has been shown that waste pomegranate peel extract is suitable for natural dyeing of wool fabric. In their study by Tutak, Acar and Akman (2014); in another of his works; 100% woolen fabric is dyed with natural dyes using plant sources of mint (*Mentha spicata* L.) and thyme (*Thymus vulgaris* L.). Before the dyeing process, woolen fabrics were mordanted with iron (II) sulfate at different concentrations according to the pre-mordanting method. After the natural dyeing process, the color quality of colored fabrics was examined with K/S color yield, CIE L* a* b* color coordinates and various fastness tests. In the study of Eyüpoğlu (2020); Linen fabric samples were dyed using natural dyestuff obtained from wild cornflower, using conventional methods and microwave energy. Before dyeing, all samples used tin chloride, copper sulfate, iron sulfate, ascorbic acid, potassium aluminum sulfate and potassium dichromate mordants according to the pre-mordanting process. The color darkness value, CIELab value and fastness value of the samples obtained were examined in terms of the type of mordant used and the dyeing method.

MATERIAL AND METHOD

Material

In painting; dried leaves of the Tetra plant, which grows in the rural areas of Edirne province, as a dyestuff and as a textile material; 4/3 Nm warp 100% wool yarn, as mordanting agent; Iron sulfate ($FeSO4$) and Copper sulfate ($CuSO4$) were used.

Method

Using dried leaf parts of the Tetra plant, wool yarn samples were dyed by dyeing methods without and with mordant. The amount of mordant was used at 3% based on the weight of the wool yarn. Plant weight was taken as 100% (based on yarn weight) and dyeing was done in a thermostat water bath. Color measurements of the obtained colors were made with an E-Rite brand portable spectro photometer, and color yield (K/S) values were calculated. Within the scope of the study, dyeing without and with mordant was carried out. Dyeing was carried out using 2 different mordants at 3% and 5% rates.

Color yield (K/S) was also calculated using the following.

$$K/S = \frac{(1-R)^2}{2R} \qquad (1)$$

R: Reflection of light of a known wavelength through fabric

K: Absorption coefficient

S: Scattering coefficient.

RESULTS AND DISCUSSION

The colors and color tones obtained by dyeing wool yarns using tetra leaves without or using mordant are shown in Figure 1. Tetra leaf dyed wool yarns a) without mordant b) With %3 $CuSO_4$ Mordant c) With %5 $CuSO_4$ Mordant d) With %3 $FeSO_4$ Mordant e) With %3 $FeSO_4$ Mordant

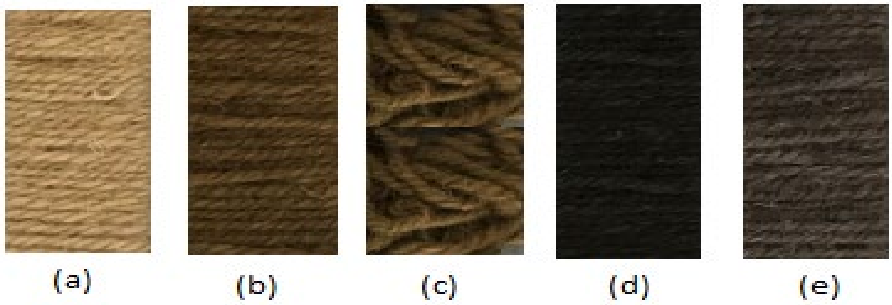

Figure 1. Tetra leaf dyed threads a) Without mordant b) With %3 $CuSO_4$ Mordant c) With %5 $CuSO_4$ Mordant d) With %3 $FeSO_4$ Mordant e) With %3 $FeSO_4$ Mordant

K/S (color efficiency) values of wool yarn samples dyed using tetra leaves were measured using wavelength with the help of a handheld spectrophotometer, the screenshot of which is shown in Figure 2.

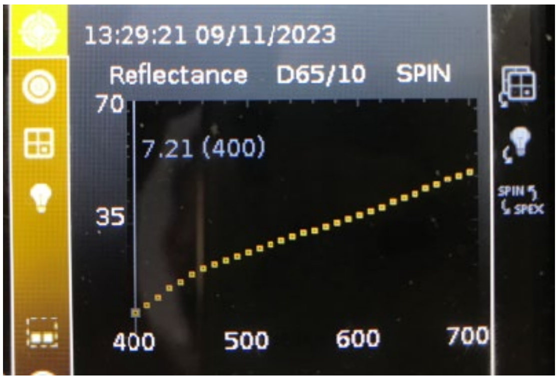

Figure 2. Color efficiency determination with differences in wavelength

CuSO4 with mordant, 3% FeSO4 with mordant, 3% FeSO4 with mordant are compared, when the differences between dyeing with and without mordant are examined, the largest K/S value (color efficiency) is 16.26 with 5% CuSO4 mordant. It was determined that the lowest value was 0.27 in samples without mordant.

When the values obtained in Table 1 and the graph in Figure 2 are examined, the dyeing concentration affects the color efficiency.

Table 1. Wavelength and K/S values of tetra leaf dyed wool yarns (a) Without mordant b) With %3 $CuSO_4$ Mordant c) With %5 $CuSO_4$ Mordant d) With %3 $FeSO_4$ Mordant e) With %3 $FeSO_4$ Mordant)

Wavelength (nm)	Tetra Leaf without mordant	%3 $CuSO_4$ Tetra leaf	%5 $CuSO_4$ Tetra leaf	%3 $FeSO_4$ Tetra leaf	%5 FeSO4 Tetra leaf
	K/S	K/S	K/S	K/S	K/S
400	6.20	16.20	16.26	2.62	14.50
410	4.53	15.41	15.52	2.83	11.22
420	3.34	13.81	14.12	3.07	8.81
430	2.58	12.61	12.75	3.30	7.32
440	2.15	11.40	11.46	3.48	6.52
450	1.83	10.21	10.13	3.62	6.04
460	1.61	8.99	8.75	3.72	5.76
470	1.45	7.80	7.52	3.77	5.60
480	1.32	6.81	6.37	3.80	5.52
490	1.22	6.08	5.63	3.81	5.48
500	1.13	5.51	5.01	3.81	5.47
510	1.05	5.03	4.56	3.81	5.47
520	0.98	4.58	4.11	3.82	5.45
530	1.11	4.25	3.80	3.82	5.42
540	0.86	3.95	3.50	3.83	5.39
550	0.80	3.69	3.25	3.86	5.32
560	0.76	3.45	3.02	3.90	5.23
570	0.71	3.27	2.83	3.96	5.12
580	0.67	3.04	2.65	4.03	4.98
590	0.63	2.87	2.50	4.13	4.82
600	0.59	2.71	2.35	4.24	4.63
610	0.55	2.53	2.20	4.38	4.43
620	0.51	2.34	2.06	4.55	4.21
630	0.47	2.17	1.92	4.76	3.98
640	0.43	2.03	1.81	4.98	3.75
650	0.40	1.91	1.71	5.23	3.52
660	0.37	1.80	1.63	5.52	3.30
670	0.34	1.71	1.56	5.86	3.07
680	0.31	1.63	1.50	6.21	2.86
690	0.29	1.54	1.43	6.63	2.65
700	0.27	1.48	1.38	7.12	2.45

The wavelength and K/S values of tetra leaf dyed wool yarns are given in detail in Table 1. When wool yarns dyed without mordant, 3% CuSO4, with mordant, 5%.

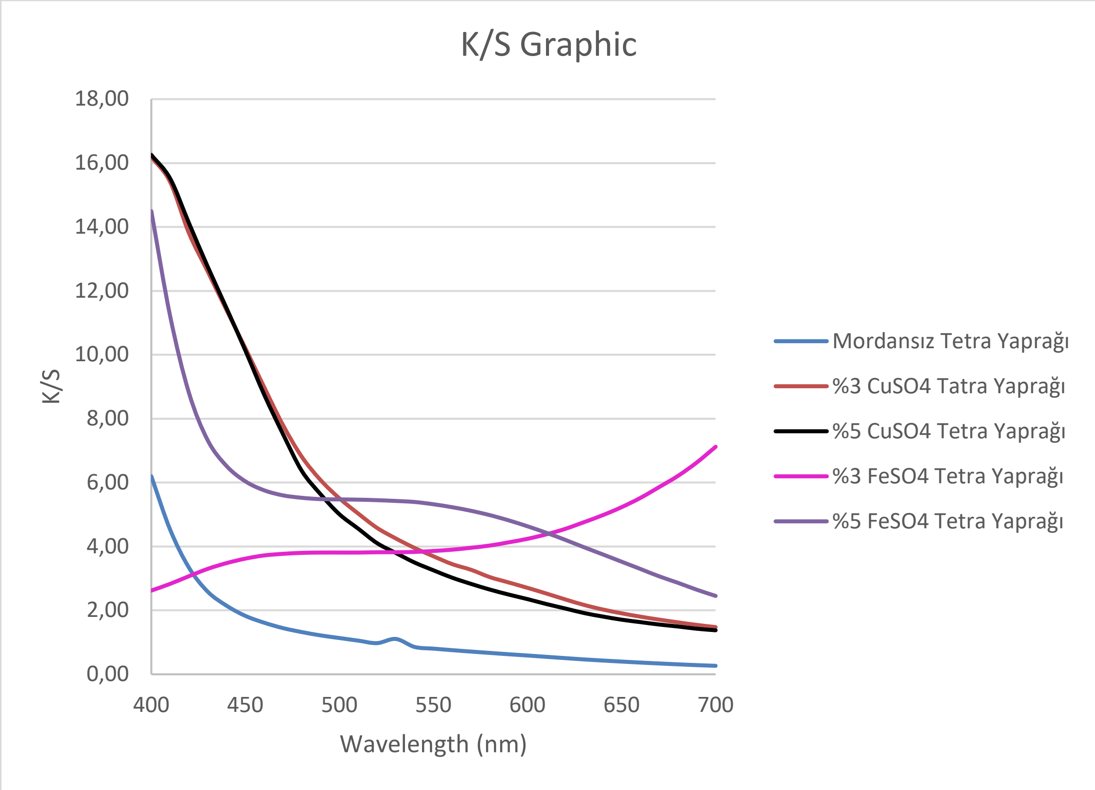

Figure 2. Graph of wavelength and K/S values of tetra leaf dyed wool yarns (a) Without mordant b) With %3 $CuSO_4$ Mordant c) With %5 $CuSO_4$ Mordant d) With %3 $FeSO_4$ Mordant e) With %3 $FeSO_4$ Mordant)

CONCLUSION

In this study, wool yarns supplied from the market were dyed with tetra leaves in various ways with and without mordant, and the color differences on these dyed yarns were tried to be determined and compared. Wool threads dyed with natural dye; under dyeing conditions, it can be affected by various parameters such as dye concentration with and without mordant, dyeing temperature and time, and different colors can be detected. In this way, efforts were made to introduce new colors to the range of colors that can be obtained with natural dyes.

With this study, it becomes important to increase environmental awareness and increase the use of natural dyes. It is recommended to carry out various fastness tests for dyeings, especially for the popularization of natural dyes. In this way; it should be ensured that it contributes to environmentally friendly painting.

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EXAMINING THE COLOR DIFFERENCES OF FABRIC LAYERS ON THE SAME PASTEL WITH A HANDHELD SPECTROPHOTOMETER

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ABSTRACT

Fabric color harmony, which is among the most important issues in businesses for production in the clothing and apparel sectors, is also important between different parts of a garment.

In order to make mass production in the garment industry, the fabrics are left to rest for a certain period of time under ambient conditions and are adapted to the ambient conditions such as heat, humidity and other similar factors, and are laid on top of each other in the desired number of layers. This fabric block is prepared for the cutting process in accordance with all the garment pattern pieces placed on it. In particular, checking whether there is a faulty fabric layer during cutting should be carried out during laying. In this way, color differences that may exist between coats are prevented from being reflected on the produced product. For this process, metaling or marking is required, especially in order to match the parts with the same layer.

In this study; we will try to focus on the color differences of the layers between the fabric markers and the detection of these color differences with a hand spectrophotometer.

Keywords: Fabric, Fabric Paste, Fabric, Color differences, Handheld Spectrophotometer.

INTRODUCTION

Fabric and color harmony, which is among the important issues in the production phase of the clothing and apparel sectors, is also important between different parts of a garment. Although it may not be noticed at first when the same color appears in different tones on the fabric, it can be clearly understood over time with washing and environmental factors.

For mass production in the garment industry, fabric pastes are created by resting the fabrics in ambient conditions for a certain period of time and laying them on top of each other in the desired number of layers to make them suitable for the environmental conditions such as heat, humidity and other similar factors. This fabric block is prepared for the cutting process in accordance with all the garment pattern pieces placed on it. In particular, checking whether there is a faulty fabric layer during cutting should be carried out during laying. In this way, detection of color differences and fabric defects between layers is prevented before the product is produced. For this process, metaling or marking is required, especially in order to match the parts with the same layer. In this way, we have the opportunity to save time, employee effort, energy and other factors.

In this study; the color differences of the layers between the fabric markers and the detection of these color differences by means of a hand spectrophotometer will ensure fabric and color harmony in order to produce an aesthetic and functional product.

In the study of Pamuk and Yıldız (2016); they examined the effects of fabric width, lay shape and autolay layout strategy on layout efficiency in two different upper garments. 64 marker plans were created using the Gerber AccuMark V.9 CAD system, and when the marker efficiency rates were compared, the highest efficiency values were obtained when working with 160 cm fabric width for both models. Additionally, high efficiency values were achieved with face-to-face laying method. In Yılmaz (2020) study; the dyeing of woolen fabric samples was carried out by using herbal sources in the ratio of 1:1 and 1:3 in proportion to the weight of the fabric, choosing a liquor ratio of 1:70 to golden herb. Brown and yellow tones were obtained in woolen fabrics by using different mordant substances, and the color values were determined with the help of a spectrophotometer. In the studies of Bilgiç and Duru Baykal (2016); In order to use the fabric efficiently, cutting layout plans (lay drawings) were prepared for the pattern numbers and pattern shapes of six different models of knitted upper group garments, in three different fabric widths and in four different fabric types, using the Gemini Nest Expert program. Model type, fabric width and fabric shrinkage values were chosen as independent variables, and marker efficiency was chosen as the dependent variable. The data obtained was analyzed and interpreted. In the studies of Baykal and Göçer (2012); he evaluated the efficiency and quality while working on different models with different fabric types in a garment company. The process numbers and times, cutting layout efficiencies, band efficiencies and second quality rates of the selected models were determined and compared. It tried to determine the suitability of fabrics and models for working in the enterprise.

MATERIAL AND METHOD

Materiel

Colorful pastel fabric laid in a ready-made clothing production company was used. Color differences between layers were detected.

Method

The color values of the color differences of each layer, respectively, of the pastel layers obtained by laying the dark blue colored fabric in 69 layers were calculated with the E-Rite brand portable spectrophotometer device. Within the scope of the study, the L*a*b*¬C*h* values of the same colored fabric samples colored on the pastel were evaluated.

RESULTS AND DISCUSSION

The color differences of the pastel layers obtained by laying the dark blue fabric in 69 layers are shown in daylight in Figure 1.

Although the product is obtained by using pieces obtained from the same marker layer, color differences are often caused by different factors such as light, perspective on the product, and dyeing errors of the fabric, creating color differences on the product as seen in Figure 2.

L*a*b*¬C*h* values of the same colored fabric samples colored on the same marker were measured with the help of a spectrophotometer. When color differences are examined between fabric layers, the largest L* value is 25.63 in the third sample, the smallest L* value is 17.62 in the thirty-fifth sample, the largest a* value is 2.09 in the forty-third sample, the smallest a* value is 0, 34 to the twenty-sixth sample, the largest b* value is -15.64 in the third sample, the smallest b* value is -19.51 in the sixty-first sample, the largest C* value is 19.61 in the sixty-first sample, the smallest C* The highest h* value was 13.84 in the thirty-seventh sample, the largest h* value was 276.17 in the nineteenth sample, and the smallest h* value was 271.35 in the thirtieth sample. These values are given in detail in the chart in Table 1.

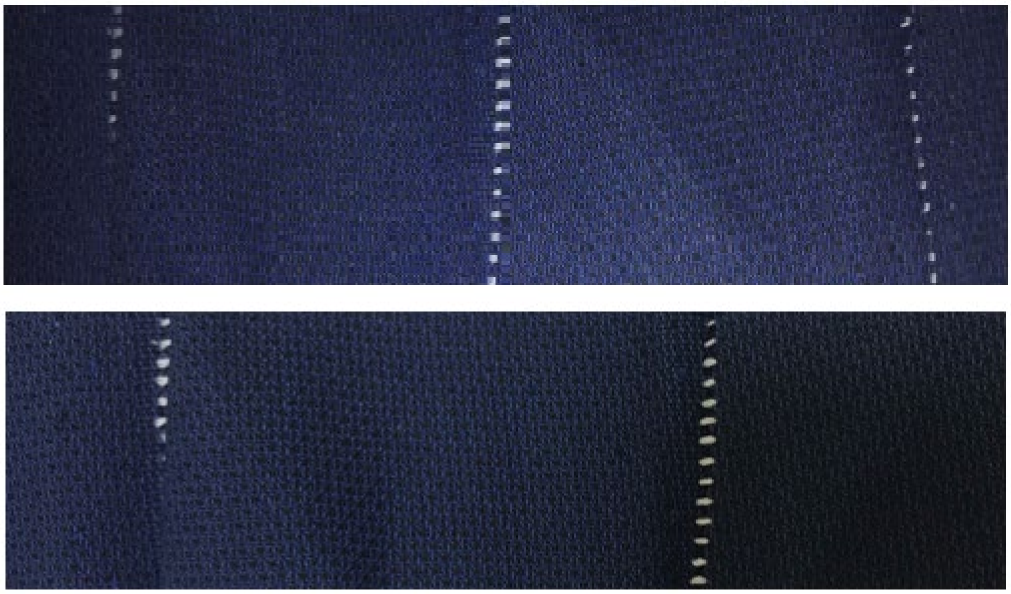

Figure 1. Pastel layers

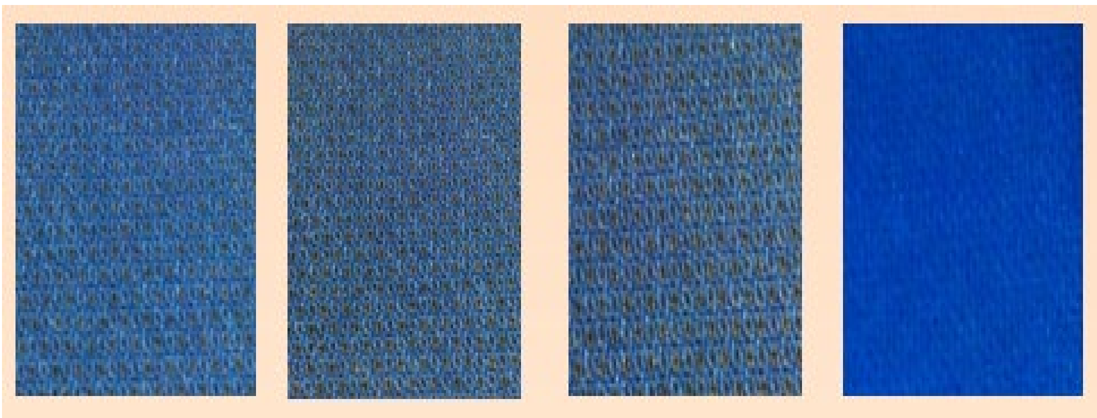

Figure 2. Color differences of pastel fabric samples at different light intensities (Şen and Becenen, 2017)

The presence of different values in different layers of the marker layers may be due to weaving, knitting, type of fabric, dyeing conditions and all other external effects.

Table 1. CIELAB (L*, a*, b*, C*ve h°) values of the samples obtained as a marker

	L	a	b	C	h
1	21.17	1.03	-18.02	18.05	273.29
2	18.13	0.75	-16.26	16.26	272.66
3	25.63	0.81	-15.64	15.66	272.97
4	21.02	0.97	-17.79	17.81	273.11
5	21.79	0.84	-18.21	18.23	272.64
6	21.95	0.97	-17.98	18.00	273.10
7	21.94	0.99	-17.76	17.79	273.20
8	21.99	1.01	-17.98	18.01	273.21
9	22.40	0.80	-17.75	17.76	272.59
10	19.34	0.77	-16.45	16.47	272.66
11	21.99	0.98	-18.18	18.21	273.09
12	22.18	0.92	-18.26	18.29	272.88
13	22.23	0.83	-17.80	17.82	272.66
14	18.33	0.72	-16.30	16.32	272.51
15	21.57	2.03	-18.73	18.84	276.17
16	22.01	2.04	-19.21	19.32	276.07
17	21.86	2.02	-18.99	19.10	276.07
18	21.63	2.00	-19.21	19.31	275.94
19	21.45	2.06	-19.16	19.27	276.15
20	21.43	1.80	-18.85	18.94	275.46
21	21.69	1.93	-19.22	19.32	275.75
22	21.67	1.91	-18.86	18.95	275.77
23	21.64	2.02	-18.96	19.07	276.09
24	21.76	1.97	-19.00	19.11	275.93
25	22.35	0.45	-18.11	18.12	271.41
26	18.12	0.34	-15.64	15.64	271.24
27	22.08	0.59	-17.84	17.85	271.90
28	22.20	0.83	-18.24	18.26	272.61
29	22.11	0.75	-17.83	17.85	272.41
30	22.06	0.42	-17.74	17.75	271.35
31	21.94	0.71	-17.91	17.92	272.28
32	21.74	0.82	-17.52	17.54	272.67
33	22.71	0.47	-18.03	18.18	271.48
34	22.52	0.58	-18.18	18.19	271.84
35	17.62	0.63	-15.81	15.82	272.27
36	22.33	0.50	-17.73	17.73	271.62

37	22.38	0.65	-13.83	13.84	272.67
38	22.29	0.73	-17.98	17.99	272.33
39	18.78	0.63	-16.68	16.69	272.17
40	22.05	1.76	-19.33	19.41	275.22
41	22.17	1.66	-19.29	19.37	274.91
42	18.12	0.79	-15.87	15.89	272.84
43	21.22	2.09	-18.83	18.95	276.34
44	22.43	1.48	-18.26	18.68	274.53
45	22.47	1.49	-18.68	18.73	274.56
46	22.01	0.45	-17.62	17.62	271.47
47	21.47	1.71	-18.36	18.44	275.34
48	21.76	1.10	-18.01	18.04	273.48
49	22.34	0.74	-17.99	18.00	272.34
50	21.84	0.49	-17.68	17.68	271.58
51	21.56	1.29	-18.21	18.26	274.06
52	22.50	0.86	-18.01	18.03	272.74
53	22.47	1.09	-18.69	18.72	273.32
54	21.39	1.77	-18.74	18.82	275.38
55	21.91	1.96	-19.39	19.48	275.78
56	21.74	2.03	-19.37	19.48	275.99
57	21.38	0.82	-17.43	17.45	272.71
58	21.37	0.84	-17.87	17.89	272.69
59	21.65	1.97	-18.89	18.99	275.97
60	22.07	1.69	-19.25	19.32	275.00
61	21.71	1.97	-19.51	19.61	275.77
62	21.14	1.88	-19.02	19.11	275.64
63	22.09	1.75	-19.40	19.48	275.16
64	21.38	1.85	-19.16	19.26	275.78
65	21.74	1.85	-19.45	19.54	275.43
66	22.28	1.79	-19.13	19.21	275.33
67	21.93	0.91	-17.94	17.96	272.90
68	20.37	1.34	-16.90	16.95	274.53
69	21.47	0.59	-17.90	17.91	271.89

CONCLUSION

In this study, it was tried to detect and compare the color differences in the layers on the pastel spread fabrics supplied from ready-made clothing enterprises. Determining the color differences between the first dyed fabric head and the last dyed fabric of fabrics dyed by various methods, and the colors of textile products that should be used in the same color; it can be affected by various parameters such as dye concentration, dyeing temperature and dyeing time. For this purpose, in this study, the color differences between the pastel layers were determined and it was tried to reveal in which layers the color differences occurred.

With this study, we tried to examine in which pastel layers the same shades of the desired colors differ, and it is important to increase these and similar studies on pastel color differences. Although the width of the fabric, the way it is laid out and the way it is placed are among the most important factors affecting marker layers, detecting color differences is also important for marker and fabric grading.

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DISTRIBUTION AND ADAPTATION OF THE NATURAL RED DYE PLANT *RUBIA TINCTORUM* L.

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ABSTRACT

Throughout history, madder (*Rubia tinctorum* L.) has been the plant most used by people to obtain red color. Madder is a perennial herbaceous species in the Rubiaceae family. The red-colored parts are root-stem structures that develop under the soil and are called rhizomes. This plant is of Iranian-Turanian origin; its natural distribution is the region from Northwest and Central Asia to the Northwest Himalayas and west, south and southeast of Europe. It is generally accepted that its homeland is the Eastern Mediterranean Region. It spreads from sea level to 2000 m altitude. Today, it is also distributed in parts of Western Europe, North Africa and the Americas.

Madder is a plant of temperate and warm climates. The plant is found wild in bushes, on the edges of fields and settlements, in wastelands and gardens. It lives mostly in the spaces of cultivated and raised gardens and fields, along roads and walls. It grows well in moist and semi-shady places, in stream beds, in humus-rich, chalky-clay, clayey-sandy, deep soils that are not too wet and arid.

Keywords: *Rubia tinctorum*, madder, ecology, distribution

INTRODUCTION

Since ancient times, human beings have painted using many different materials. The use of dyestuffs in plants emerged at the beginning of the Bronze Age, and starting from this period, around 300 plant and animal natural dyestuffs were used (Genç, 2014). It is known that dye plants were grown and used in the centers where carpet-rug weaving and handicrafts developed in Anatolia for a long time. However, with the easier and cheaper production of synthetic dyes in the early 19th century, the production of dye plants and the use of natural dyes decreased all over the world.

Today, it is generally understood that synthetic dyes pose a danger to human health and the environment. It is known that some of these products are allergic to humans and even have carcinogenic effects, and also harm the environment (Kayabaşı, 2002; Karadağ, 2007). For this reason, interest in natural dyes and dye plants has begun to increase again. It is known that in recent years, some European countries have imported vegetable dyes and started to carry out projects for the production of dye plants. In our country, dye crop cultivation is almost non-existent. The ever-increasing demand for natural dyestuffs is met by collecting them from nature. This practice poses a significant threat to plants in the natural flora. For this reason, studies on the cultivation of wild dye plants are planned (Anon., 2003).

One of the most important plants in carpet and textile dyeing throughout the ages has been madder (*Rubia tinctorum* L.; Eyüboğlu et al., 1983). Historical records show that this plant was used by many societies to produce red color, starting from 3250 BC until the end of the 19th century (Eşberk and Köşker, 1945; Harmancıoğlu, 1955; Karadağ, 2007; Genç, 2014). The Turkish Red/Edirne red color called Alizari, which gained great fame until the mid-19th century, is produced from the roots of this plant (Ateş, 1960; Karadağ, 1997). It is known that madder cultivation has been practiced in Anatolia since ancient times (Deveoğlu et al., 2022). Today, the cultivation of this plant has completely disappeared in our country. However, the increasing interest in natural dyes brings the cultivation of madder plants back to the agenda. For this reason, it is of great importance to know the plant characteristics of *Rubia tinctorum* L. and to reveal its ecological and agronomic requirements. In this paper, the madder plant was introduced and its distribution areas and ecological requirements were discussed in detail.

MADDER (*Rubia tinctorum* L.)

Rubia tinctorum L. belongs to the Dicotyledon class and the Rubiaceae family within the plant kingdom. The Rubiaceae family is the fourth most populous family in the world, with 620 genera and 13,600 species (Davis et al., 2009; Govaerts et al., 2012). In Turkey, this family is represented by 13 genera and 174 species. The Rubia genus, which falls into this family, includes approximately 88 species distributed in temperate and hot regions (Anon., 2022). These species are herbaceous or semi-shrub-like, sometimes climbing plants. Leaves emerge from the same node, on average, 4-6 pieces. The flowers form clusters emerging from the leaf axils or tips. The color of the flowers is cream or yellowish-green. The fruit is hemispherical in shape and fleshy.

People have obtained a significant portion of dyestuffs from plants since ancient times. It is possible to obtain colors such as yellow, green, brown and purple from various plants. However, there are very few plants that produce red color. The most important of these is the madder plant known by its scientific name *Rubia tinctorum*. The madder plant is popularly known as "root dye, dyer's root, dye herb, dye freckle, dye purser, stick dye, sky dye, red root, sticky herb and tongue-winging herb" (Figure 1). The parts of *Rubia tinctorum* that give its red color are root-stem structures called rhizomes that develop in the soil. These rhizomes grow up to 1 m and spread everywhere like couch grass. Although the aboveground parts dry out during the winter, the underground structures maintain their vitality and shoot again the following year. The thickness of the rhizomes is 1.5-3 cm, depending on the age of the plant.

Figure 1. Madder (*Rubia tinctorum* L.)

DISTRIBUTION OF MADDER

Rubia L. genus includes 88 species distributed in temperate and hot regions (Anon., 2022). All species in this family contain dyes, especially in their roots.

However, it is known that *R. tinctorum* is richer in this respect. This plant is of Iranian-Turanian origin; It has spread from Northwest and Central Asia to the Northwest Himalayas and to the west, south and southeast of Europe (Davis, 1982). It is generally accepted that its homeland is the Eastern Mediterranean Region. It spreads from sea level to 2000 m altitude. The regions where it spread naturally in the world and where it was later introduced can be seen in Figure 2.

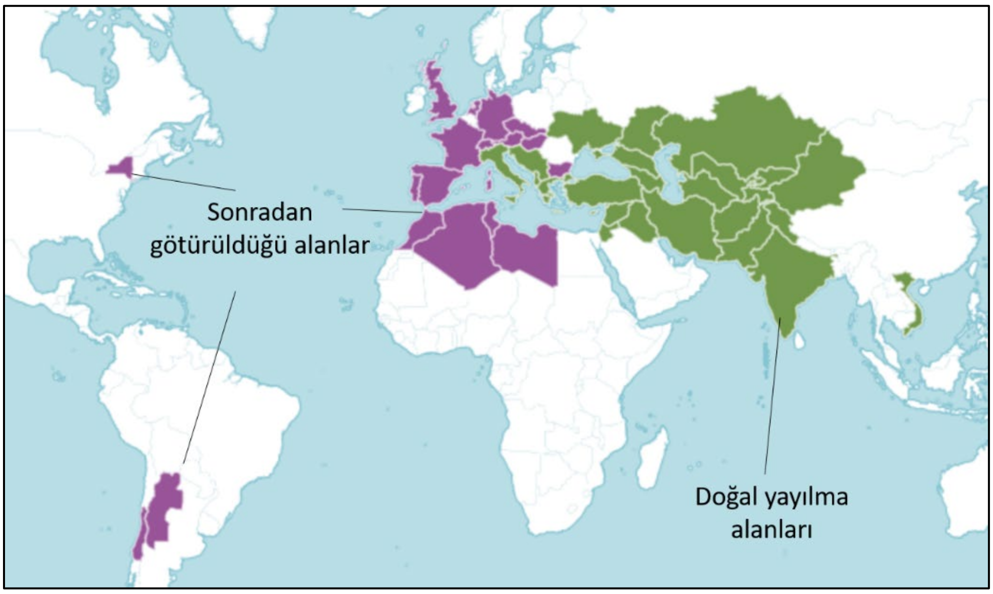

Figure 2. Distribution areas of *Rubia tinctorum* L. in the world (Anon., 2022)

There are 5 Rubia species in Turkey. These are *R. tinctorum L., R. peregrina L., R. davisiana Ehrend., R. rotundifolia* Banks & Sol. and *R. tenuifolia* d'Urv (Davis 1982; Semen et al., 1989; Karabacak, 2012). Three subspecies of *R. tenuifolia* species have been identified. The species seen in Turkey are given in Table 1 (Karabacak, 2012) and the distribution areas of *Rubia tinctorum* are given in Figure 3 (TÜBİVES, 2023).

Table 1. Species of the Rubia genus in Turkey

Latin Name	Turkish Name	Endemism
Rubia tinctorum L.	Kökboya	-
Rubia peregrina L.	Yabani kökboya	-
Rubia rotundifolia Banks & Sol.	Bostanboyası	-
Rubia davisiana Ehrend	Boyapürü	Endemic
Rubia tenuifolia d'Urv.	Kızılboya	-
Rubia tenuifolia subsp. *brachypoda* (Boiss.) Ehrend. & Schönb.-Tem.	Boyaçili	-
Rubia tenuifolia subsp. *doniettii* (Griseb.) Ehrend. & Schönb.-Tem.	Çöpboyası	-
Rubia tenuifolia subsp. *tenuifolia* d'Urv.	Kızılboya	-

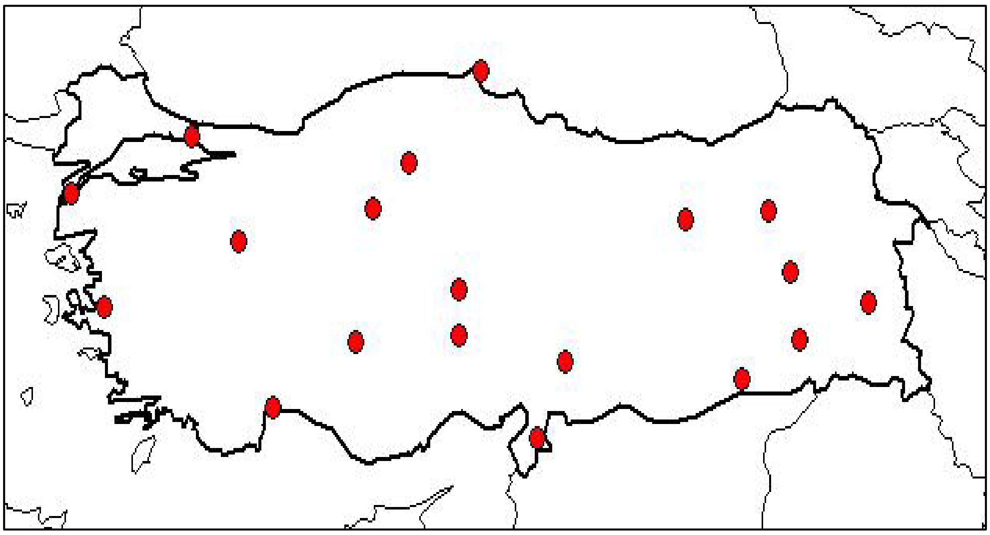

Figure 3. Distribution areas of *Rubia tinctorum* (madder) in Turkey (TÜBİVES)

In botanical research, this plant has been recorded only around Istanbul and Gallipoli in the Thrace region. However, this does not mean that the plant is not found in Thrace. There are many samples collected from the Thrace Region in Trakya University EDTU Herbarium. It is seen that their distribution areas in our country are mostly concentrated in Western Anatolia and the Aegean Region (Balıkesir, Manisa, Afyon, Denizli, Uşak). Akyürek (2001) states that madder was used in Western and Central Anatolia in the 19th century. It states that it was cultivated until the end of the 19th century, and that the forms found in the natural flora were common in areas where agriculture had been previously practiced. Probably wild populations are forms that have adapted to natural life from cultural forms over a period of hundreds of years.

CLIMATE AND SOIL REQUIREMENTS

Madder is a plant of temperate and warm climates. Since it is a perennial species, it spends the winter period underground as a rhizome and begins to germinate and grow at the beginning of April under Thracian conditions (Tan et al., 2022). The madder plant, which remains green throughout the summer, blooms in mid-July and ripens its seeds in September, drying the aboveground parts. Although it is known as a heat-loving Mediterranean plant, madder grows in very different climates. In a study conducted in Iran, it was reported that it is distributed between 75-1900 m altitudes and the climates of the regions where it grows vary from cool and humid to hot and arid environments (Baghalian et al., 2010). The flexibility in climate requirements is due to the fact that madder plants spend the negative period underground.

The plant is found wild in bush areas, on the edges of fields and settlements, in vacant lands and gardens (Başlar and Oflas, 1996; Akyürek, 2001). Madder is not found in pasture areas with dense vegetation and dry and dense soil. It lives mostly in the gaps of cultivated and raised gardens and fields, and on the edges of roads and walls. It grows well in moist and semi-shaded places that are not too wet and dry, in stream beds, in humus-rich, calcareous-clayey, clayey-sandy, deep soils (Şanlı and Çatalkaya Gök, 2017). Başlar and Mert (1999) reported that *R. tinctorum* prefers fertile, salt-free, organic matter-rich, medium-rich phosphorus and potassium-rich soils. The soils of the places where it grows are generally neutral or slightly alkaline (LaBerge, 2018). Khorsandi and Banakar (2011) determined that it was salt resistant during the germination stage, and that the 50% decrease in germination (threshold value) occurred at a salinity level of 12 dS/m. The highest germination occurs at 15-25 ºC.

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ROOT DYE AS A HIGH VALUE-ADDED ALTERNATIVE PRODUCT IN AGRICULTURE

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ABSTRACT

Agricultural activities are prevalent in Edirne district, constituting a significant portion of the local economy. Therefore, agricultural production and outputs play a crucial role in the district's development. The main crops cultivated are wheat, sunflower, paddy, and corn. This study will analyse the potential of the *Rubia tinctorum* L. plant as a non-food industry product. As an alternative to food sector inputs, the root dye plant has potential as a textile sector input. *Rubia tinctorum* L. is the source of the root dye used to obtain Edirne red and can provide inputs for various sectors with different dye needs. Additionally, its historical background offers potential for creating a strong brand image. This study economically analyzes the potential of the root dye plant as an alternative crop to wheat and sunflower, under similar climate and soil conditions. The results indicate that the root dye plant has a high profit potential and the absolute profit at the end of the year is approximately 14 times higher than that of wheat and sunflower. For the third year, the productivity of root dye is higher, resulting in an absolute profit approximately 60 times higher than the other crops. However, it should be noted that the costs incurred to achieve this high profitability are also quite high when compared to root dye. Instead of one decare of root dye can grow 14 decares of wheat or 21 decares of sunflower. This cost factor may lead to alternative plantings on fallow or low-productivity land. To maximize agricultural support policies, it is recommended to focus on seedling cultivation, as it accounts for sixty five percent of the costs.

Keywords: *Rubia tinctorum* L., Edirne Red, Opportunity Cost, Profitability Analysis

INTRODUCTION

Throughout history, dyes have been produced using a variety of plants and animals. However, with the growth of the textile industry, the cost of natural dyes has increased due to their limited availability. In 1869, Alizarin, previously only obtained from roots, was synthesized for the first time. The low cost of synthetic dyes compared to natural root dyes led to the widespread use of chemical dyes (Yıldırım, 2014: 15-16). In the 21st century, legal restrictions have been imposed on the use of chemical dyes in textile and dyeing industries due to their negative effects on the environment and human health (Angelini et al., 2003: 200). Synthetic dyes can cause allergies, damage human skin, and cause environmental pollution (Genç, 2014: 177). As a result, there is a growing demand for natural dyes. This demand has brought Edirne Red, which has a historical reputation, back into focus. Edirne Red has two different meanings. There are two reasons why Edirne Red is a popular colour: its brightness and durability, and the process used to obtain it. Edirne Red is a natural dye extracted from the root of the *Rubia tinctorum* L. plant, which was traditionally used to dye fabrics. This dye produces a unique and vivid red colour that is brighter and darker than European tile red (Şanlı and Gök, 2017: 772). The dye is commonly referred to as Turkish Red or Edirne Red in literature due to the high-quality production in Anatolia, particularly in the Edirne region (Yıldırım, 2014: 16). This study analyses the productivity and profitability of root dye production in the Edirne region.

It is known that agricultural production is concentrated on the food industry. Economically, the share of non-food agricultural production is quite low. In this study, an economic analysis of *Rubia tinctorum* L. as an alternative agricultural product was carried out as a non-food industry product. It can be used as a colouring agent (root dye) in many sectors, especially in textile sector. *Rubia tinctorum* L. plant, which will be an input to the textile sector as an alternative to the products that constitute input to the food sector, also has a historical aspect. *Rubia tinctorum* L. plant, which is the source of the root dye from which Edirne red is obtained, has the potential to create raw materials for sectors such as medicine, pharmacy and weaving industry as well as meeting natural dye needs. It also has the potential to create a strong brand image thanks to its marketing and historical background. In this study, the plant will be analysed economically as an alternative crop for wheat and sunflower, which have the highest production area under similar climate and soil conditions. Due to its potential to produce high added value and being an industrial agricultural product, it is recommended to be planted outside of wheat and sunflower cultivation areas. It should be considered as an economic alternative crop for cultivation areas with low productivity. The data used in the analysis belong to Edirne region. The findings obtained indicate that root dye is more profitable than wheat and sunflower. The high initial investment cost restricts production in very wide areas. Implementation of the support and incentive policy for areas with low productivity will ensure that root dye production does not disrupt the production of strategic crops such as wheat and sunflower.

MATERIALS AND METHODS

The primary agricultural crops cultivated in the Edirne region are wheat, sunflower, corn, and paddy. Root dye cultivation, which is considered an alternative to wheat and sunflower, can be grown in areas with similar climatic conditions and soil structure. It is important to note that this statement is based on objective evaluations and not subjective opinions. Therefore, *Rubia tinctorum* L. was chosen as a substitute for wheat and sunflower. While economic reasons are the primary consideration for selection, it is also important to note that the plant has historical and cultural roots in the Edirne region.

CALCULATION OF COSTS

This study compares and contrasts the cultivation methods of wheat, sunflower, and root dye, each with its own associated costs. The cost differences arise from the varying planting and harvesting periods of the crops. To ensure accurate comparison of the products, the differences in costs between planting and harvesting periods were taken into account.

The cost of wheat was calculated taking into account the prices from the previous year. Because wheat is sown in previous year and harvested in the following year. The data for wheat costs are obtained from the Chamber of Agriculture of the region. As wheat cultivation can involve both dry and irrigated agriculture, the calculated costs represent the average of these two methods.

Sunflower production differs from wheat production in that sunflowers are planted and harvested in the same year. When calculating costs, detailed items were taken into account and average costs were calculated separately for dry and irrigated agriculture. The costs for sunflowers were obtained from the regional Chamber of Agriculture.

In contrast to wheat and sunflowers, root dye plants are perennial. They can be harvested from the first year, but their productivity increases every year. As the third year is typically the most productive, the costs for root dye were calculated separately for the first and third years.

When determining the costs of root dye, we considered the results obtained from the project 'Determination of the Agricultural Potential of Natural Dye Plant Root Dye (*Rubia tinctorum* L.) in Edirne Conditions' conducted at Trakya University Havsa Vocational College (Tan et al., 2022). We also obtained some cost elements from the regional Chamber of Agriculture, as wheat production and root dye production share similarities. In addition we calculated cost considering Baydar and Karadoğan's (2006) essay which considered a seedling of 5300 per decare, 25 cm plant spacing, and 75 cm row spacing.

For the third year's harvest of root dye, the data of Havsa Vocational Collage and the regional chamber of agriculture were used.

The cost elements for wheat, sunflower, and root dye were calculated during the period in which they were incurred. On the other hand, sales prices and profitability were calculated for the harvest period to eliminate any mismatch between expenses and income.

COMPARISON OF ROOT DYE PROFITABILITY AS AN ALTERNATIVE PRODUCT

For the years 2020-2022, wheat and sunflower revenues will be calculated based on the average prices of the month with the highest volume of purchases following the harvest season. In 2023, prices for wheat and sunflower will be based on the most recently announced month since the harvest season has not yet started. The sales prices of the products will be taken from the official datas announced by Edirne Commodity Exchange Market, Trakya Birlik and Turkish Grain Board.

As root dye is not currently traded in agricultural product exchanges, the lowest prices from both foreign and domestic online sales channels were considered to calculate the minimum income from root dye.

The cost and income of wheat, sunflower, and root dye were compared over a three-year period. This is because root dye is a three-year crop, while wheat and sunflower are one-year crops. Root dye can be harvested in the first year, but the highest yield is reached at the end of the third year. Therefore, we first compared the results for the first year and then conducted a profitability analysis for the third year when the root dye yield was at its peak.

Table 1 shows the yield per decare in kg, gross production value per decare, costs per decare, costs per kg, profit in absolute value, and relative profit for wheat, sunflower, and root dye in 2022.

Table 1. Profitability of wheat, sunflower and root dye at 2022 prices

	Wheat	Sunflower	Root Dye
Year	2022	2022	2022 (1st year)
Yield (Kg/da)	425,00	180,00	94,40
Price (TL/kg)	4,91	12,54	450,00
GDP (TL/da)	2.086,75	2.257,20	42.480,00
Production Cost (TL/da)	918,00	1.476,00	25.703,23
Unit cost (TL/kg)	2,16	8,20	272,28
Absolute Profit (TL)	1.168,75	781,20	16.776,77
Relative Profit (%)	2,27	1,53	1,65

Source: Compiled from Edirne Commodity Exchange Market, Turkish Grain Board and Chamber of Agriculture data.

In 2022, the average wheat productivity was 425 kg, with a cost of 918 TL per decare and a return of 2,086.75 TL. On average, wheat producers made a profit of 1,168.75 TL per year, resulting in a 127% profit in the income-expense comparison.

Similarly, the average productivity for sunflower in 2022 was 180 kg, with a cost of 1,476 TL per decare and a return of 2,257.20 TL. It was observed that the wheat producer made an average profit of 781.20 TL at the end of one year. The income-expense comparison revealed a profit margin of 53%.

The results for root dye in 2022 showed an average yield of 94.40 kg, a cost of 25,703.23 TL per decare, and a return of 42,480.00 TL. These results indicate a profit margin of 65% for root dye in the income-expense comparison.

In this comparison with 2022 prices, two points should be taken into consideration. One point to note is that while wheat production yields the highest profit, root dye production can be even more profitable than sunflower production. Another important consideration is that while root dye production can be highly profitable, the costs can be equally high.

The root dye plant is a perennial crop, and its productivity increases every year. Therefore, a long-term comparison is necessary. According to studies in the literature, root dye productivity can reach 171 kg per decare in the third year. Therefore, extending the comparative analysis to three years would be appropriate and would provide the opportunity for a long-term analysis. Table 2 presents the costs and returns for the past three years, calculated using realized prices. A profitability comparison is made with root dye at the end of the third year. The prices for 2020, 2021, and 2022 were obtained from official institutions to ensure accurate results, rather than estimates.

Table 2. Profitability comparison of wheat, sunflower and root dye (3 years)

	Wheat			Sunflower			Root Dye	
Year	2020	2021	2022	2020	2021	2022	1st Year	3rd year
Yield (kg/da)	450,00	450,00	425,00	180,00	180,00	180,00	94,40	171,00
Price (TL/kg)	1,86	2,50	4,91	4,00	5,70	12,54	450,00	450,00
GDP (TL/da)	837,00	1.125,00	2.086,75	720,00	1.026,00	2.257,20	42.480,00	76.950,00
Production Cost (TL/da)	697,50	733,50	918,00	585,00	774,00	1.476,00	25.703,23	16.031,25
Unit Cost (TL/kg)	1,55	1,63	2,16	3,25	4,30	8,20	272,28	93,75
Absolute Profit (TL)	139,50	391,50	1.168,75	135,00	252,00	781,20	16.776,77	60.918,75
Relative Profit (%)	1,20	1,53	2,27	1,23	1,33	1,53	1,65	4,80

Source: Compiled from Edirne Commodity Exchange Market, Turkish Grain Board and Chamber of Agriculture data.

Table 2 shows that the high inflation environment in Turkey has increased profit rates for both wheat and sunflower. In 2020, the relative profit for wheat was 1.2, which increased to 2.27 in 2022. Similarly, the relative profit for sunflower increased from 1.23 in 2020 to 1.53 in 2022.

The profitability of root dye was also calculated according to years, with the relative profit increasing from 1.65 in first year to 4.8 in the third year when the yield is maximum. Assuming 2022 as the first year, the absolute profit at the end of the year is approximately 14 times higher than that of wheat and sunflower. However, there is no significant advantage in root dye in terms of relative profit. Assuming 2022 as the third year, the productivity of root dye is higher, resulting in an absolute profit approximately 60 times higher than the other crops.

In a highly inflationary environment, comparing and understanding prices becomes challenging. Hence, it would be more comprehensible to compare with present prices rather than retrospective analysis. Table 3 illustrates the comparison based on current prices. The estimated price of root dye for 2024 was calculated based on the expected exchange rate.

Table 3. Profitability of wheat, sunflower and root dye at 2023 prices

	Wheat	Sunflower	Root Dye	
Year	2023	2023	2023 (1st Year)	2023 (2nd Year)
Yield (kg/da)	500,00	230,00	94,40	170,00
Price (TL/kg)	8,25	14,00	1.595,00	2.392,50
GDP (TL/da)	4.125,00	3.220,00	150.568,00	406.725,00
Production Cost (TL/da)	3.410,00	2.585,20	77.946,00	88.558,00
Unit cost (TL/kg)	6,82	11,24	584,58	520,93
Absolute Profit (TL)	715,00	634,80	72.622,00	318.167,00
Relative Profit (%)	1,21	1,25	1,93	4,59

Source: Compiled from Edirne Commodity Exchange Market, Turkish Grain Board and Chamber of Agriculture data.

Productivity figures were obtained from the results of the 'Determination of the Agricultural Potential of Natural Dye Plant Root Dye (*Rubia tinctorum* L.) in Edirne

Conditions' project carried out at Trakya University Havsa Vocational Collage. It is important to note that although studies in the literature report a root dye yield of 171 kg in the third year, non the less, Trakya University Havsa Vocational Collage project results indicate a productivity of 170 kg in the second year.

Table 3 shows that the cost per decare for wheat at 2023 prices is 3,410 TL and the return is 4,125 TL, resulting in a realized profit of 715 TL per decare. For sunflower, the cost per decare is 2,585.2 TL, the return is 3,220 TL, and the absolute profit is 634 TL. In the case of root dye, the cost per decare is 77,946 TL in 2023 prices, while the return is 150,568 TL, resulting in a profit of 72,622 TL per decare in the first year. This analysis shows that the profitability rate for wheat and sunflower is approximately 20%, whereas the profitability rate for root dye is 93%.

Trakya University Havsa Vocational Collage's project exceeded expectations in the second year, producing 170 kg of root dye per decare. Although the productivity of root dye increased in the second year, the elimination of planting costs significantly increased profitability. For the year 2024, taking into account the increase in the exchange rate, the estimated costs are 88,558 TL, the estimated return is 406,725 TL, and the estimated profit is 318,167 TL. These results suggest the possibility of excessive profits in root dye.

CONCLUSIONS AND RECOMMENDATIONS

This study compares the cost and return of root dye plants as an alternative crop to wheat and sunflower, using three different methods. The first method uses realized prices from 2022, the second uses a retrospective 3-year period, and the third uses non-final prices from 2023.

The results show that root dye outperformed wheat and sunflower in terms of absolute profit based on one-year harvest yield results. Nevertheless, no significant difference was observed in relative profit rates. However, when comparing the yields of the second and third years, the profitability of root dye was found to be higher. Yet the high initial investment costs for root dye producers limit their production in wide areas. It is possible to grow more than 20 decares of wheat or sunflower with the cost of growing one decare of root dye. As seedlings represent the largest expense in the initial investment, it would be advisable to introduce support and incentive policies in this area. Furthermore, collaboration with universities and agricultural institutes is crucial for seedling cultivation, which accounts for 65% of the first-year costs in root dye cultivation.

The by-product seed from root dye cultivation can generate additional income and contribute sustainability of production. This feature reduces seedling costs and provides input to the health sector.

However, there is marketing problems when it comes to realizing profits despite the attractive profitability levels of the production process. Therefore, promoting the product, marketing, and creating a market can be considered prerequisites for industrial production. However, to ensure the healthier functioning process, companies demanding root dye should plan the production period with producers through long-term contracts.

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GLAZED COLOR OF GLAZED TONGUE TILE “CORAL RED”

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ABSTRACT

Tile is made from clay that is shaped after firing and used to make pots, plates, vases, jugs, etc. İt is a traditional art based on producing objects. The art, which started to be used in the 9th century, developed in the 13th century, when Seljuk architecture reached its peak, and with the Ottomans, traditional tile art gained a brand new dimension. Traditional tile art, which is the most colorful form of interior and exterior decoration, started to show its great and continuous development in the 14th century.

The tiles of the first Ottoman period, in Bursa Yeşil Mosque and Tomb, Bursa Muradiye Mosque, Edirne Muradiye Mosque and Çinili Köşk, are made with mosaic or glazed painting techniques, in dark blue, blue, turquoise and black colors, with more geometric patterns. The Ottomans, who abandoned this style, started to use the underglaze painting technique and in the 16th century, in the Iznik workshops, it brought a visuality and pleasure that is difficult to achieve to the tile art in terms of biscuit quality, pattern variety and color richness.

Coral Red, the legendary color of Traditional Turkish tiles, which started to be used in the 1550s, disappeared in a period of approximately 55-60 years, leaving its color to a brownish red in the early 1600s. Although the masters who pursued this lost secret managed to revive Iznik tiles, even today's technology could not reach coral red. The artist who can come closest to this color is Faik Kirimli, known for his research on Iznik tiles.

Keywords: Tile, Red, Traditional

INTRODUCTION

The word tiling is widely used for both glazed wall coverings and household items such as pots and pans. In the Ottoman period, pottery forms were called "evani" and wall coverings were called "kashi". The word çini, which means "belonging to

China" in Persian, originates from the Ottoman palace's admiration for 15th-century Chinese porcelain.

To describe it, it is the application of patterns by drilling and transferring metal oxide paints with coal powder to the hard plate obtained by firing the hand-pressed biscuit plate, which is formed by mixing tile, kaolin, quartz, clay and dolomite in certain proportions, at 900 degrees Celsius (first firing). After the colors are painted, the work is coated with glaze and takes its final form with the second firing.

HISTORICAL DEVELOPMENT OF TRADITIONAL TURKISH TILE ART

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The rapid development of tile art from the beginning of the 13th century continued its victory with increasing enrichment until the end of the century under the dominance of the mosaic tile technique, which was most compatible with architecture. The brick decoration seen in the first Turkish architecture in Anatolia was replaced by glazed brick and tile covering. The 13th century Seljuk tile art showed an unprecedented development, far surpassing the art of the pioneer and contemporary circles, and became a genuine source for the tile art of the coming centuries. There is no work outside Anatolia that can rival the mosaic tile decoration used in Seljuk art throughout the 13th century. In Seljuk tile art, there is a rich and diverse worldly atmosphere created by figured tiles in Seljuk palaces, as opposed to the abstract decorations of the mosaic tile technique that fit the solemn atmosphere of religious buildings. The power of a painting art dating back to the Uyghurs can be felt in the figured tiles colored with minai, glazing and underglaze techniques. However, Anatolian tile art has created a unique world of patterns with an astonishing creative force. Symbolic figures that the Seljuks loved very much participated in the compositions. The dominance of vegetable motifs in tile decoration, which increased after the second half of the 13th century, was a harbinger of the naturalist style that was approaching towards the end of the century.[1]

Its radical artistic development, which started with the Great Seljuks, continued with the Anatolian Seljuks. The unique Seljuk architecture, which developed in Anatolia in the 13th century, is the product of a synthesis. The first technique appears as the "glazed brick technique" used during the Anatolian Seljuk period. In this technique, where turquoise, cobalt blue, eggplant purple and sometimes black are used, we see that glazed and unglazed bricks are arranged horizontally, vertically, zigzag or diagonally. In this period, plain colored decorations consisting of triangles, quadrangles, squares and hexagons were also used.

Another widely used technique is the "mosaic technique" that the Seljuks introduced to our art. It is a technique that is used very successfully in interior spaces, mihrabs, domes, and transitions to the dome. Examples of the mosaic technique made by inlay are called "inlay mosaic technique". Different techniques are encountered in religious and civil architectures and palaces. Minai, luster (polishing) and underglaze technique are among the tile techniques. We see that they are applied on unusual cross and star forms, such as the minai technique used in Konya Alaaddin Palace. Some of the colors used in this technique, such as purple, blue, brown, turquoise, green, red and black, are fired under glaze, while the remaining colors are painted on the glaze and fired again.

The luster (polishing) technique, of which we see many examples in the Kubadabad Palace, is an overglaze technique in which the prepared patterns are painted with a mixture of a mineral oxide called luster, silver and copper alloy, on a previously glazed and fired surface. In the technique where brown and yellow are used more intensively, floral motifs, human and animal figures are widely used.

Many plain and gilded tiled wall decorations belonging to the Anatolian Seljuk period, designed as squares, hexagons and triangles and using single colors of purple, turquoise and cobalt, are known. However, we know that in some samples that were colored and fired, the overglaze gilding samples faded away over time due to the lack

[1] Yetkin, Ş., 1972. Development of Turkish Tile Art in Anatolia, Istanbul, p. 206-207.

of a second firing. We also encounter examples of this type of technique in the early Ottoman architecture of the 15th century.

In many researches and excavations carried out in Anatolia, single-coloured glazed and unglazed works, along with examples of scraping (sgraffito) and slip painting techniques, thought to date back to the 13th century, were found.

In the underglaze technique, the works are obtained by painting, glazing and firing predominantly turquoise, purple, blue, cobalt, green and black colors on the biscuit plate on which the pattern is transferred, as the name suggests.

With the establishment of the Ottoman state, Turkish tile art gained a new vitality and style. The biggest innovation that Ottoman tile art brought to Turkish tile art was the use of the "colored glaze technique".[2] This technique, dated to the end of the 14th century and the beginning of the 15th century, is cuerda seca. The paste color is red and the lining is white. It has a variety of colors including turquoise, yellow, lilac, cobalt, black, pistachio green and gilt. The printed or engraved patterns were painted with colored glaze and baked by applying wax or a chemical substance to the contour gaps. This method prevents the dyes from mixing with each other during the baking stage. The patterns generally consist of plant-based motifs, geometric motifs, kufic and thuluth script ornaments with verses.[3]

RED COLOR USED IN TURKISH TILE ART AND ITS DEVELOPMENT

The red color used in the tiling technique was the first step towards the development of this color in Turkish tile art. The use of new colors and the development towards naturalistic motifs are collected in these works. The features of the use of red color are characteristic of the early Ottoman tile art. The brilliant development in Seljuk tile art came to a halt during the Principalities period and made a new move with various techniques used in the early Ottoman period. This paved the way for the success achieved by Ottoman art in the second half of the 16th century by

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[2] Yetkin, Ş.,a.g.e, s. 208
[3] Turan Bakır, S, 1999. İznik Çinileri ve Gülbekyan Kolleksiyonu, Ankara, s.11.

using only the underglaze technique, and the naturalistic style of high Ottoman tile art, given in a liveliness that almost emanated from nature, had its final say with the successful application of the red color in underglaze relief, which had been sought after since the Seljuks.[4]

Starting from the 15th century, white dough, which has a thin and dense texture, began to be used. In Iznik workshops, until the beginning of the 16th century, white hard paste, white slip under transparent glaze, and the dominance of colors such as blue, turquoise and dark blue were used, as well as the color lilac. In the examples produced in the Iznik workshops in the first quarter of the 16th century, it is seen that light and dark blue, turquoise, cumin green, eggplant purple and cinnamon brown colors were used under the glaze. During this transition to multi-colour, it is seen that the eggplant purple gives way to the magic of the red color and passes through the preparation phase for the fluffy coral red.

The color red was actually used in Anatolian tile art in various periods, with slightly different color tones, with various techniques. Dark red color applications that are not fluffy under the glaze began to show itself in plates, vases and wall decorations on a white background, and in many works with lace-edged leaves, tulips and carnations. We see that the first place where the fluffy coral red color under glaze was used was on the mihrab border of the Suleymaniye Mosque and on the Chinese cloud motifs (Picture 1, 2, 3, 4). In the Iznik workshops, the tile masters tried to master the ultimate technical superiority of the plain (non-fluffy) red color. We come across many examples in the leading museums of Turkey and the world. In addition to many museums that we can list, especially the Louvre Museum, Victoria and Albert Museum, Portuguese Calouste Gülbekyan Museum, Topkapı Palace, Tiled Pavilion, Rüstem Pasha Mosque, Sultan Ahmet Mosque, Mihrimah Sultan Mosque, Sokullu Mehmet Pasha Mosque, Piyale Pasha Mosque and Takkeci İbrahim Ağa Mosque. We can see examples of it in many religious architectural structures such as.

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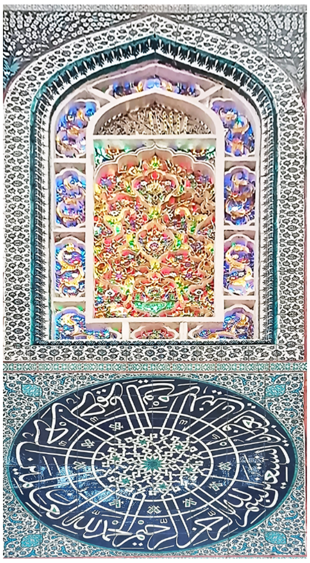
[4] Yetkin, Ş.,a.g.e, s. 209



Picture 1. Süleymaniye Mosque
Mihrap Panel

Picture 2. Süleymaniye Mosque
Mihrap Panel- Detail

Picture 3. Süleymaniye Mosque
Mihrap Panel

Picture 4. Süleymaniye Mosque
Window pediment-Detail

Another work with the most magnificent examples of coral red color is the panels located on both sides in the mihrab section of Edirne Selimiye Mosque, and especially the Rumili medallion parts in the middle part of the panels, the panels with tulips in the triangular areas (lion chest) on the columns at the entrance to the women's section and the Hünkar. Next to the mahfili panels, the apple panel, of which there are very few examples in the world, can be shown (Picture 5, 6, 7, 8).

Picture 5. Selimiye Mosque Mihrap Panel- Detail

Picture 6. Selimiye Mosque Mihrap Panel- Detail

Picture 7. Selimiye Mosque Hunkar Mahvili-Detail

Picture 8. Selimiye Mosque Hunkar Mahvili-Detail

CONCLUSION

Iznik, an important cultural and tile production center since ancient times, is the place where the fascinating beauty of tiles and ceramics reaches its peak. Each piece of tiles and ceramics, the most important cultural heritage of Turkish tile art, has been admired by art lovers, collectors and scientists in the world and Anatolian geography for years. Each work has become a symbol of creativity and imagination for centuries.

Tile masters were invited from Khorasan and Bukhara, and the Ottoman Empire captured the culture that existed before it and turned it into an art that was difficult to reach. Iznik tiles reached their peak in the 16th century with the development of the Ottoman Empire and palace support, and turned into a very magnificent and important art form that we exported to the world. Iznik tiles are in the underglaze technique and are based on quartz and its derivatives. It is produced entirely by hand, without pressing, using traditional methods.

We call the purified and separated form of every soil we set foot on mineral oxide. Dark blue is cobalt oxide, copper oxide is turquoise, copper dioxide is green, manganese oxide is purple or brown, chromium oxide is black... The curious color, red, is obtained from iron oxide.

Color tones occur depending on the amount or amount of these oxides. Let's come to coral red. In the traditional method, a wood-burning oven is used. If the fever is low, the red will be light; if it is high, the red will be dark. We believe that coral red, the most important color of Iznik tiles and ceramics of the 16th century, is not a natural dye, but a mixture obtained as a result of careful effort that requires a long time. Although the exact formula is unknown, the pigment of coral red is iron sulfate. When preparing coral red, it is thought that medicinal ones should be preferred rather than commercial and industrial iron sulfates and the iron oxide rate should be less than 70%.[5]

The color called fluffy coral red or tomato red under glaze in Ottoman tile art was seen in tiles and ceramics for 55-60 years, starting from the 1550s until the early 1600s. The opinion that emerged is that there is no record of the formula of the coral red color, which left its mark on Turkish and world art for a short time, and that the master did not share the secret formula with anyone and that it probably became a secret after the master's death and was lost in the pages of history. Even though many contemporary artists and masters who were fascinated by Iznik tiles and coral red have managed to revive Iznik tiles, no one has been able to reach the secret of coral red. The artist who can come closest to this color is Faik Kırımlı, known for his research on Iznik tiles.

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[5] The Story of Tile and Coral Red, https://www.gzt.com/nihayet/cini-ve-mercan-kirmizinin-hikayesi (11.10.2020).

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Photos, Nergis Çanak, 2022-2023.

INFLUENCE OF BIO-MORDANT TREATMENT ON DYEING PROPERTIES OF WOOL FABRIC DYED WITH NATURAL DYE EXTRACT OBTAINED FROM MADDER PLANT (*RUBIA TINCTORUM* L.)

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ABSTRACT

As nations become more conscious of the toxicity of synthetic dyes that are hazardous to the environment and human health, there is an increasing interest in natural dyes in the dyeing of textiles industry. Several opportunities have been to use biobased plant-derived colorants to develop sustainable textile dyeing processes. Applying gall oak and pine cone extract as bio-mordants and madder (*Rubia tinctorum* L.) as a natural dye, a sustainable dyeing procedure was created. Bio-mordanted wool fabrics at the rates of 3%, 5%, and 10% were dyed with madder. The influence of bio-mordants versus metal mordants (such as alum and iron sulfate) for color measurement and color fastness of a natural dye extract on wool fabrics was investigated. After the dyeing process, the color of each dyed wool fabric was investigated in terms of the CIELAB (L*, a*, and b*) values. The K/S values of wool fabrics that had been dyed were measured and qualities including wash and rubbing fastnesses were determined using ISO standard methods.

Keywords: Wool fabric, natural plant dyes, bio-mordants, fastnesses tests, CIEL*a*b*,

INTRODUCTION

Natural dyes have traditionally been used to color natural textiles including cotton, silk, and wool since time immemorial (Karadag, 2022). One of the oldest practices of ancient civilizations was the use of natural colorants for dyeing (Mandal and Venkatramani, 2023; Yadav et al., 2022). The natural colorants were used both as dyes and in the form of dye pigments, mostly dye lakes. Important groups of ancient dyes were anthraquinone reds (*Kermes vermilio, Rubia tinctorum*) (Melo, 2023). The first synthetic dyes were invented (Nagendrappa, 2010) by William Henry Perkin in 1856, which caused a change in the situation. As a result of their many applications, including those in food, synthetic dyes gradually gained greater acceptance (Prabhu & Bhute, 2012). Despite this, over the past few decades, the use of synthetic dyes has been steadily declining because of growing environmental consciousness and negative impacts brought on by either their toxicity or non-biodegradable nature. Flavonoids, anthraquinones, and indigoid compounds make up the majority of the coloring agents in dyes derived from plants (Mishra, Singh, Gupta, Tiwari, and Srivastava, 2012).

Madder, a plant that was historically used to color fabrics and was native to Europe (Casadio, Leona, Lombardi, and Van Duyne, 2010), the Middle East (Karapanagiotis, Abdel-Kareem, Kamaterou and Mantzouris, 2021), and India (Devi Priya and Siril, 2014), was extracted from the dried roots of the shrub *Rubia tinctorum* L. In the winter, the plant's upper parts die, and in the spring, new twigs grow from the twig roots (Clementi, Nowik, Romani, Cibin and Favaro, 2007). The plant can reach a height of approximately 1.5 meters. Madder plant is a rich source of dye plant; the yield of dye from the roots of a three-year-old madder plant is 3-5 tons per hectare, while the dyestuff is in the range of 150-200 kg (Ozdemir and Karadag, 2023). Nearly all of Turkey's regions are suitable for root dye cultivation because the plant grows in moist, shady environments (Kayabaşı and Dellal, 2004).

In this study, Bio-mordanted wool fabrics at the rates of 3%, 5%, and 10% were dyed with madder. The dyeings comply with the Natural Organic Dye Standard (NODS)(Karadag, 2023). Following the dying procedure, the color of each colored wool fabric was studied using CIELAB (L*, a*, and b*) values. The K/S values of colored wool fabrics were determined. ISO standard procedures were used to determine properties such as wash and rubbing fastness.

MATERIAL AND METHOD

Material

The weight of the wool woven fabric was 200 g/m^2. The warp density per cm of the woven fabric is 12, and the weft density per cm is 10. The warp yarn is Nm 10 and weft yarn count is Nm 10. Pine cone wood specimens were obtained from Marmara region (Istanbul, Turkey). Madder plant was provided by Natural Dyes Doğal Boya Hammaddeleri San.ve Dış Tic. Ltd. Şti. (Istanbul, Turkey).

a. b. c.

Figure 1. a. Gall oak b. Pine cone c. Madder

Method

The procedure of the mordanting and dyeing

The dyeing of wool fabrics was carried out with the traditional aqua method. Table 1 summarizes the coloring process.

Color measurement

The investigation of color characteristics of wools was conducted using a Datacolor Spectraflash SF 600 + (Datacolor International, USA) instrument with a specular-included mode and an LAV 30 mm viewing aperture. Measurements were carried out at 20±2 °C temperature (65±2 % relative humidity) and D65 daylight and 10° standard observer.

Fastness properties

Wool fabrics that had been colored underwent washing and rubbing tests in keeping with ISO105: C06 (A1S) and ISO105-X12 standards, respectively. The ISO 105.

Table 1. Dyeing procedure

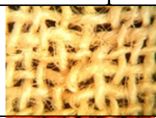
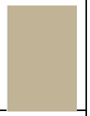
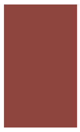
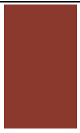
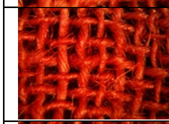
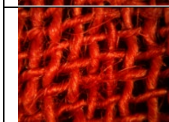
Code	Mordantingagent		Mordanting (%)	Dyeing (%)	Temp. (^0C)		Time (min)		pH		Shade	
					Mord.	Dye.	Mord.	Dye.	Mord.	Dye.	Microscope	Real
WR	-		-	-	-			-	-			
W0	-		0	50	90	90	60	60	-			
W1	Alum	Metallic mordant	10						3-4	4-5		
W2	Iron		3						4-5	4-5		
W3	Gall oak	Bio-mordant	3						6-7	6-7		
W4			5									
W5			10									
W6	Pine cone		3						7-8	6-7		
W7			5									
W8			10									

Table 2. CIELab values of dyed wool samples

Code	Mordanting agent	Mordant %	Dyeing %	*L**	*a**	*b**	C*	h°	*K/S*	*ΔE**
WR	-	-	-	73,96	1,77	16,69	16,96	64,01	-	-
W0	-	-		38,71	30,98	19,49	36,6	32,17	-	-
W1	Alum	10		35,55	35,22	25,98	43,76	36,42	18,74	45,73
W2	Iron	3		27,76	12,45	14,48	19,1	49,31	24,25	47,73
W3		3		35,83	25,98	15,82	30,42	31,34	18.98	42.08
W4	Gall oak	5		35,32	25,2	17,57	30,53	34,77	20.20	45,17
W5		10		32,93	24,64	17,75	30,6	35,54	25.57	45,7
W6	Pine cone	3	50	33,51	26,55	13,55	29,81	27,03	14.99	47,72
W7		5		30,9	24,54	14,41	28,69	30,43	15,81	48,65
W8		10		30,58	26,27	15,36	30,15	30,15	18.90	49,97

RESULTS

Wool fabrics bio-mordanted at the rates of 3%, 5%, and 10% were dyed separately with a madder (*Rubia tinctorum* L.). Wool fabrics were dyed with the application of gall oak and pine cone extracts as bio-mordant. Also to evaluate, metallic mordants 10% alum and, %3 iron pre-mordanted versus bio-mordan dyed wool fabrics were investigated. Bio-mordanting is an innovative method of creating new colors with great fastness properties and usually involves tannin- and ionic-structured compounds (Zhang et al., 2022).

The age of the plant affects the composition and concentration of anthraquinone chemicals in madder, and *Rubia tinctorum* colors are anthraquinone dyes. Alizarin is one of the primary dyestuffs (Ferreira, Hulme, McNab and Quye, 2004). There have been 36 different anthraquinones reported from Rubia in addition to the main anthraquinone, alizarin. The anthraquinones included in Rubia tinctorum vary in the nature of their substituents and in their substitution pattern (Derksen, Niederländer and van Beek, 2002). Pine cone, a popular agricultural waste, was investigated as a bio-mordant. Anatolian black pine (*Pinus nigra* subsp. *pallassiana*) wood specimens were obtained from Marmara region. Anatolian Black Pine forests have the largest spread area (approximately 2.200.000 ha. of total forest area), but its use in the pulp and paper industry is insufficient, and there is no research on the suitability of this wood species for the domestic paper industry in Turkey (Ateş & Kirci, 2007). The components of pine cones contain lignin, cellulose, and tannin. The gall oak, which is most common in the Marmara and Black Sea regions, is a large-topped tree that can grow to be 12 meters tall and 80 centimeters in diameter. The leaves of gall oak do not usually fall in the autumn. When winters are mild, the loss of leaves might extend until spring. From Sumerian times to the present, it has been used to make dyes and inks. This plant includes a variety of chemical components, including alkaloids, flavonoids, saponins, and tannins.

Along with affecting the color shade or the K/S value, the different bio-mordant concentrations also changed the CIEL*a*b* values. AS shown in Table 2, the sequence of color intensity (K/S value) of different dyed fabrics is W5 > W2> W8 > W4. The higher K/S value and darker color of the sample are attained after dyeing with gall oak. To evaluate, metallic salts of Al and Fe were also used versus bio-mordant. It has been found that the application of 10% of Al, and 3% of Fe salts before dyeing wool with rubia dye has given excellent results, Overall, 3% of Fe as a pre-mordant has given excellent results. The color difference (ΔE*) values of samples were found in the range of 42.08 to 49.97 respectively, when the sample "WR-coded" was used as a standard. The highest color difference value was found as 42.97 for the sample coded W8 bio-mordanted (10% owf.). The color fastness to washing, rubbing, and light of the examined dyed wool samples are summarized in Table 3. The results of testing on the washing fastness of dyed wool fabrics were good but not the same for all fabrics. When compared to a bio-mordant, the washing fastness results of pine cones are better than those of gall oak. The result of rubbing fastness is also generally good and desired grade. As a consequence, these bio-mordant sources are capable of producing reliable test findings and are practicable from a commercial viewpoint.

Table 3. The results of light, rubbing, and washing fastness tests of dyed woven wool fabrics

Dying code	Mordanting agents	Mordanting	Dyeing (%)	Light fastness	Rubbing fastness		Washing fastness - Staining					
		(%)			Dry	Wet	Acetate	Cotton	Nylon 6.6	Polyester	Acrylic	Wool
W1	Alum	10		3	03. Nis	02. Mar	04. May	04. May	04. May	04.May	03. Nis	03. Nis
W2	Iron	3		3	03. Nis	02. Mar	04. May	04. May	04. May	04.May	04. May	04. May
W3		3		02. Mar	03. Nis	03. Nis	04. May	02. Mar	02. Mar	04.May	04. May	04. May
W4	Gall oak	5		02. Mar	03. Nis	02. Mar	04. May	02. Mar	02. Mar	04.May	04. May	04. May
W5		10	50	02. Mar	03. Nis	02. Mar	04. May	02. Mar	02. Mar	04.May	04. May	04. May
W6	Pine cone	3		02. Mar	03. Nis	02. Mar	04. May	04. May	03. Nis	03.Nis	04. May	04. May
W7		5		02. Mar	03. Nis	03. Nis	04. May	04. May	03. Nis	03.Nis	04. May	04. May
W8		10		3	03. Nis	03. Nis	04. May	04. May	03. Nis	03.Nis	04. May	04. May

CONCLUSION

The main aim of this research was to examine the dyeing characteristics of wool in combination with alternative bio- mordants (such as gall oak and pine cone) and common metallic mordants (such as alum and iron sulfate) to determine whether it would be feasible to replace the common metallic mordants with these natural alternatives as renewable resources. Wool textiles bio-mordanted at 3%, 5%, and 10% mordanted rates were dyed separately with a madder (*Rubia tinctorum* L.). Wool fabrics were colored using gall oak and pine cone extracts as bio-mordants. Further, the dyeing effects of wool fabrics were compared to those of metallic mordant and bio. The results of this study show that pine cone powder particularly is an efficient bio-mordant for the natural dyeing of wool.

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OPTIMIZATION OF SOLVENT EFFECT ON THE TOTAL EXTRACTIVE MATTER AND ANTIOXIDANT ACTIVITY OF MARIGOLD (*TAGETES PATULA* L.) FLOWER PETAL EXTRACTS

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ABSTRACT

Natural dyes derived from marigold (*Tagetes spp*.) flowers have emerged as an important alternative to synthetic dyes for both silk and cotton. The present study aimed to determine optimal extraction conditions from French marigold (*Tagetes patula* L.) flower petals to achieve maximum total extractive matter (TEM) and the highest antioxidant activity (AOA), using 66.8% ethanol and hexane as solvents. To determine the optimal conditions, a Custom Design (SAS JMP software TM) was used. The input variables were: solvent (hexane and ethanol); extraction temperature (40 °C, 55 °C, and 70 °C); extraction time (20 min, 50 min, and 80 min); and solvomodule (plant material:solvent ratios of 1:10, 1:20, and 1:30 m/V). The output variables were total extractive matter (TEM in mg/ml) and the concentration required to obtain a 50% antioxidant effect (EC_{50} in mg/ml). Twenty experiments were done. The extracts were obtained by reflux extraction of the air-dried and disintegrated flower petals with the chosen solvents. According to the results obtained, ethanol extracts have shown both higher AOA and TEM in comparison to hexane extracts. The optimal conditions for TEM were extraction time: 80 minutes; extraction temperature: 70 °C; solvomodule 1:10 m/V and ethanol as a solvent. Under optimal conditions, TEM (with a 95% confidence interval) should be in the range of 20.62382-23.461118 mg/ml. The experimentally determined value was 21.20 mg/ml. Optimal conditions for AOA were: solvomodule 1:10 m/V, and ethanol as a solvent. The time and temperature were not

statistically significant. According to the results obtained, with a 95% confidence interval, the EC_{50} value should be in the range of 0.032860 to 0.064466 mg/ml. The experimentally determined value was 0.0507 mg/ml. Ethanolic extracts from marigold flower petals possess strong antioxidant activity and could potentially be used in the cosmetic, pharmaceutical, and food industries as a natural antioxidant, as well as natural dyes in the textile industry.
Keywords: *Tagetes patula* L. flower petals, reflux extraction, Custom Design, antioxidant activity, total extractive matter

INTRODUCTION

In recent years, the pursuit of sustainable and natural alternatives in various scientific disciplines has gained significant attention due to growing concerns about environmental conservation and human health (Haji, 2010). This paradigm shift is particularly evident in the field of botanical research, where the exploration of plant-based resources has gained prominence. The use of botanical extracts for various applications, such as pharmaceuticals, cosmetics, and functional foods, has been an area of increasing interest, driven by the rich reservoir of bioactive compounds present in plant materials (Vastard et al., 2017).

The marigold (*Tagetes spp*.) flower represents a noteworthy subject of research due to its composition, comprising an array of bioactive constituents that hold potential for various applications (Shetty et al., 2015). Belonging to the Asteraceae family, marigold is renowned for its vivid and visually captivating flowers. Historically, marigold flowers have found cultural and traditional use, particularly in rituals and festivals, owing to their striking color and aesthetic allure (Vastrad et al., 2017). Some *Tagetes* species have ornamental significance, such as African marigold (*T. erecta* L.), French marigold (*T. patula* L.) and *T. tenuifolia* (Marotti et al., 2010). French marigold flowers and leaves are of interest due to their content of terpenes (Prakash et al., 2012; Stanojević et al., 2022); carotenoids (Piccaglia et al., 1998); thiophenes (Szarka et al., 2006), polyacetylenic sulfur compounds with strong biocidal activity that are chemotaxonomic markers of *Tagetes* spp. (Marotti et al., 2010); alkaloids (Faizi and Naz, 2002); fatty acids (Deineka et al., 2007), and flavonoids (Guinot et al., 2008; Faizi et al., 2011). Their biological activities reported to date include insecticidal

(Wells et al., 1993), nematicidal (Chadha, 1976; Buena et al., 2008), larvicidal (Dharmagadda et al., 2005), antifungal (Faizi et al., 2008), and anti-inflammatory (Yasukawa and Kasahara, 2013) activities. According to the study by Munhoz et al. (2012) French marigold flowers contain up to 5.5% of flavonoids (Munhoz et al., 2012). Besides, as a rich source of lutein and its esters (Piccaglia et al., 1998) *Tagetes patula* L. is widely cultivated in Central America as food coloring, which has been approved by the European Union as well (Vasudevan et al., 1997). Moreover, natural dyes obtained from *T. erecta* flowers have emerged as significant alternatives to synthetic dyes for textiles like leather (Pervaiz et al., 2017) and cotton (Vastrad et al., 2017).

This study aims to contribute to the existing body of knowledge by determining optimal extraction conditions by using Custom Design (SAS JMP software TM) from French marigold (*Tagetes patula* L.) flower petals to achieve maximum total extractive matter (TEM) and the highest antioxidant activity (AOA), using 66.8%[6] ethanol and hexane as solvents. To the best of our knowledge, this kind of study with French marigolds of Serbian origin was not performed.

MATERIAL AND METHODS

Chemicals and reagents

The following chemicals and reagents were used in this study: ethanol, 96% (Centrochem, Zemun, Serbia); 1,1-diphenyl-2-picrylhydrazyl (DPPH radical, Sigma Chemical Company, St. Louis, MO, USA); HPLC grade hexane (≥95%, Fisher Scientific, UK), ethyl acetate (J.T. Baker, Deventer, The Netherlands) and redistilled water.

Plant Material

The seeds of *Tagetes patula* L. (*Tagetes patula* mix 5436) were purchased in a local agricultural pharmacy (producer: Semenarna Ljubljana, Slovenia). Plant material

[6] Ethanol concentration was determined in our previous studies (optimization of ethanol concentration on the TEM and AOA of marigold flowers petals extracts by CCD - not published data)

was cultivated in the garden in the village of Garinje (municipality of Vladičin Han, Serbia; 42.7911° N, 22.1029° E). The flowers were collected in August 2022 and dried in a dark place at room temperature; packed in paper bags and left in a dark and dry place until analyzed. Before the extraction, the dried flower petals were separated from the capitula and ground in an electric grinder (Moulinex Multi moulinette 3 in 1, 500 W).

Reflux Extraction

The extracts were obtained by reflux extraction by using two solvents with different polarities (66.8% ethanol and hexane); at different extraction times (20 min, 50 min, and 80 min); temperatures of extraction (40 °C, 55 °C, and 70 °C); and solvomodules (plant material:solvent ratios of 1:10, 1:20, and 1:30 m/V).

Total Extractive Matter

The total extractive matter was determined gravimetrically, by oven drying at 105 °C until a constant weight.

DPPH Assay

The ability of the obtained extracts to scavenge free DPPH radicals was determined using the DPPH assay. The ethanolic/hexane extracts were diluted in ethanol/ethyl acetate, and a series of different concentrations (0.002-0.24 mg/ml and 0.002-1.0 mg/ml for ethanolic and hexane extracts, respectively) were prepared. Ethanol/ethyl acetate solution of DPPH radical (0.3 ml, 300 µmol solution (1.7×10^{-4} mol/L)) was added to 0.75 ml of the prepared extract solutions (”sample”) and the absorbance was measured at 517 nm after 20 minutes of incubation with the radical (A_S). Absorbance at 517 nm was determined for the ethanolic solution of DPPH radical (”control” - A_C), diluted in the aforementioned ratio (0.3 ml of the DPPH radical of the given concentration with 0.75 ml ethanol added) as well as for the ethanolic solution of extract which is not treated with DPPH radical solution (”blank” - A_B). Ethanol was used as a blank. Free radical scavenging activity was calculated according to the formula:

$$\text{DPPH radical scavenging capacity (\%)} = 100 - \left[\left(A_S - A_B \right) \times \frac{100}{A_C} \right]$$

All absorbances were measured on UV-VIS VARIAN-Cary 100 Conc. Spectrophotometer.

Experimental Design

The optimum extraction conditions to achieve maximum TEM and the highest AOA from French marigold (*Tagetes patula* L.) flower petals were determined using the Custom Design (JMP software by SAS) with three numerical variables (A, B, and C) on three levels (Table 1). The nominal variable was solvent (D). The process of designing experiments in the Custom Design consisted of the following steps: (1) defining responses, factors and factor constraints; (2) specifying the *a priori* model; (3) generating the design; (4) reviewing and evaluating the design; (5) conducting the experiment; and (6) fitting a model and predicting performance (Montgomery, 2013).

Table 1. Independent variables (numerical: A, B and C and nominal: D) and their levels used in the model design

Factors	Code	Levels		
		-1	0	1
Time of extraction (min)	A	20	50	80
Extraction temperature (°C)	B	40	55	70
Solvomodule (m/V)	C	10	20	30
Solvent	D	Ethanol (66.8%)		
		Hexane		

RESULTS

For experiment planning, data processing, and statistical analysis of the results obtained, was used the Custom Design (JMP software by SAS). The matrix of Custom Design with four factors (three numerical: A, B, and C, and one nominal: D) randomly generated by the used software is shown in Table 2. Twenty runs were done. After that, the statistical analysis of the studied factors was performed. The experimental values of the output variables (responses: TEM and EC_{50}) and predicted values of TEM and AOA (Y_1 and Y_2) subsequently performed by Custom Design are also given in Table 2.

Table 2. Matrix of the Custom Design and experimental values

Runs	Input factors (independent variables)				Output factors (responses)		Predicted Y	
	D	A	B	C	TEM (mg/ml)	EC_{50} (μg/ml)	Y_1	Y_2
	Solvent	Time (min)	Temperature (°C)	Solvomodule (m/V)			TEM (mg/ml)	EC_{50} (μg/ml)
1.	Hexane	50	55	20	0.80	225.53	1.51	194.64
2.	Ethanol	20	40	10	15.20	14.39	16.09	15.80
3.	Hexane	20	70	30	1.30	352.81	1.65	276.67
4.	Hexane	20	40	10	1.80	86.45	1.62	112.61
5.	Hexane	20	40	30	1.00	281.91	0.67	276.67
6.	Hexane	20	70	10	2.80	152.91	2.60	112.61
7.	Hexane	80	40	10	3.00	139.52	2.55	112.61
8.	Ethanol	20	70	10	22.40	16.71	21.37	15.80
9.	Hexane	80	70	30	1.20	173.04	0.22	276.67
10.	Hexane	50	55	20	1.50	274.52	1.51	194.64
11.	Ethanol	50	55	20	13.40	15.47	13.88	16.69
12.	Hexane	80	40	30	1.00	243.55	1.60	276.67
13.	Hexane	80	70	10	0.70	16.19	1.17	112.61
14.	Ethanol	50	55	20	12.40	14.42	13.88	16.69
15.	Ethanol	20	40	30	5.60	17.17	4.54	17.59
16.	Ethanol	80	70	30	10.30	24.00	10.49	17.59
17.	Ethanol	80	70	10	22.40	10.52	22.04	15.80
18.	Ethanol	80	40	30	7.90	14.61	7.57	17.59
19.	Ethanol	80	40	10	19.60	23.35	19.12	15.80
20.	Ethanol	20	70	30	9.60	16.32	9.82	17.59

The relationship between response functions (Y_1 and Y_2) and selected variables (A, B, C, D), after excluding statistically not important factors, were approximated by the following first-order polynomial function (equations 1 and 2):

$Y_1 = 7.695 + 0.4\times A + 0.975\times B - 3.125\times C - 6.185\times D - 0.5875\times A\times B + 2.65\times D\times C - 1.075\times D\times B - 0.525\times D\times A$ ....(1)

$Y_2 = 0.1056684 + 0.0889738\times D + 0.0414603\times C + 0.0405691\times D\times C$……………………... (2)

The obtained equation reveals the influence of factors and their interactions on TEM (Y_1) and AOA (Y_2), where the positive sign of the model coefficients refers to the synergistic and the negative to the antagonistic correlation. The given function refers to hexane as a solvent in both cases.

According to the results obtained (Table 2) wide range of TEM and AOA for both actual and predicted values was obtained: ~0.7-22.4 mg/ml and ~10.5-352.8 μg/ml for actual values and ~0.2-22.0 mg/ml and ~15.8-276.7 μg/ml for predicted values, respectively - Table 2.

The diagram of the correlation between the actual and predicted values is shown in Figure 1.

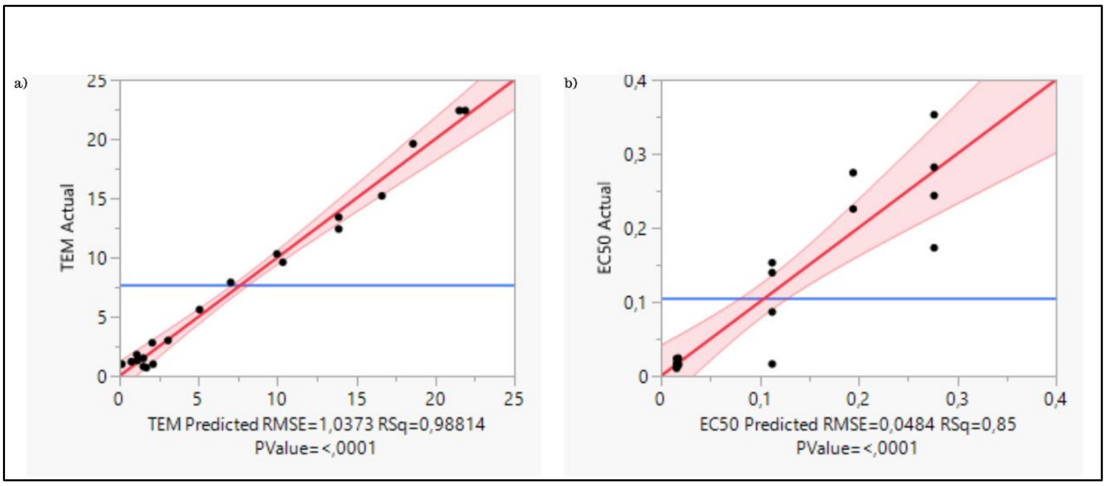

Figure 1. Correlation diagrams for (a) TEM and (b) AOA

The values of the calculated coefficients of determination (R^2) were 0.98814 and 0.85 for TEM and AOA, respectively, indicating good fitting of the estimated regression model and the data obtained for TEM. The significance of variables, their main effects, and mutual interactions on the response as well as on the statistical model are estimated by using Effect Tests, Lack of Fit and ANOVA values given in the Table 3.

Table 3. The values of Effect Tests, Lack of Fit, ANOVA and Summary of Fit for (a) TEM, and (b) AOA

(a) Total extractive matter

	Source	DF	Sum of squares	F Ratio	Prob > F
	Effect Tests (*statistically significant values)				
A	Time	1	2.56000	2.7834	0.1296
B	Temperature	1	15.21000	16.5376	**0.0028***
C	Solvo module	1	156.25000	169.8883	**<0.0001***
D	Solvent	1	765.08450	831.8648	**<0.0001***
D*A	Solvent*Time	1	4.41000	4.7949	0.0563
D*B	Solvent*Temperature	1	18.49000	20.1039	**0.0015***
D*C	Solvent*Solvo module	1	112.36000	122.1673	**<0.0001***
A*B	Time*Temperature	1	5.52250	6.0045	**0.0367***
A*C	Time*Solvo module	1	0.02250	0.0245	0.8792
B*C	Temperature*Solvo module	1	0.20250	0.2202	0.6501
	Lack of Fit				
	Lack of Fit	9	7.7575000	2.3139	0.3381
	Pure of Error	2	0.7450000	Max R^2	
	Total Error	11	8.5025000	0.9993	
	Analysis of Variance				
	Model	8	1079.8870	174.6362	**<0.0001***
	Error	11	8.5025		
	C.Total	19	1088.3895		
	Summary of Fit				
	R^2	0.98814			
	R^2 Adj.	0.986507			
	Root Mean Square Error	0.879178			
	Mean of Response	7.695			
	Observations (or Sum Wgts)	20			

(b) Antioxidant activity

	Source	DF	Sum of squares	F Ratio	Prob > F
	Effect Tests (*statistically significant values)				
A	Time	1	0.00539849	83.0165	**<0.0001***
B	Temperature	1	0.00021358	2.8306	0.1268
C	Solvomodule	1	0.02750337	0.1120	0.7456

D	Solvent	1	0.15832661	14.4210	**0.0042***
D*A	Solvent*Time	1	0.00599270	3.1422	0.1101
D*B	Solvent*Temperature	1	0.00018572	0.0974	0.7621
D*C	Solvent*Solvomodule	1	0.02633362	13.8077	**0.0048***
A*B	Time*Temperature	1	0.00706102	3.7024	0.0865
A*C	Time*Solvo module	1	0.00109095	0.5720	0.4688
B*C	Temperature*Solvomodule	1	0.00036376	0.1907	0.6726
			Lack of Fit		
	Lack of Fit	2	0.00767492	1.8031	1.8031
	Pure of Error	14	0.02979582	Max R^2	
	Total Error	16	0.03747073	0.8806	
			Analysis of Variance		
	Model	3	0.21216359	30.1979	**<0.0001***
	Error	16	0.03747073		
	C.Total	19	0.24963432		
			Summary of Fit		
	R^2		0.849898		
	R^2 Adj.		0.821753		
	Root Mean Square Error		0.048393		
	Mean of Response		0.105668		
	Observations (or Sum Wgts)		20		

The significance of the factors and the proposed mathematical model were analyzed based on the combinations of F-values and probability (p-values). The significance of each variable was assessed by analysis of variance using Fisher's statistical test. Based on the calculated high F-values ("F-ratio > 4") it is evident that the developed model indicates seven significant variations in the response of the total extracted matter, while for the antioxidant activity there are only three. Also, "Prob>F" indicates that the model terms B, C, D, A*B, D*B, D*C and D*A are statistically significant for the total extracted matter, while for the antioxidative activity the solvent, solvomodule and their interaction are statistically significant ($p<0.05$). Based on the "Effects Tests" (Table 3), it can be stated how the influence of the most significant effects decreases when it comes to TEM: solvent > solvomodule > solvent*solvomodule > solvent*extraction temperature > extraction temperature > extraction time*extraction temperature. The extraction time was not a statistically significant factor, but due to its interaction with the extraction temperature, it was retained in further analysis. All other values that are not statistically significant are excluded from further data processing. The order of effects on AOA is as follows: solvent > solvomodule > solvent*solvomodule. Other parameters are not statistically significant, so they were excluded from further analysis. In addition, the non-significant "Lack of fit" (Table 3), based on the F-ratio, confirms in both cases that the presented mathematical model (equations 1 and 2) describes well the factor influence on the response, given that the p-values are greater than 0.05 (Table 3).

Pareto Analysis

The most important factors are also presented using a Pareto diagram (Figure 2). Based on the obtained diagram, the significance of each studied factor can be clearly seen based on probability (p-value) and LogWorth value (defined as -log10p). The factor with the highest LogWorth value has the greatest effect. Therefore, from the diagram obtained, it can be seen that the solvent in both cases has the greatest influence on the total extracted matter.

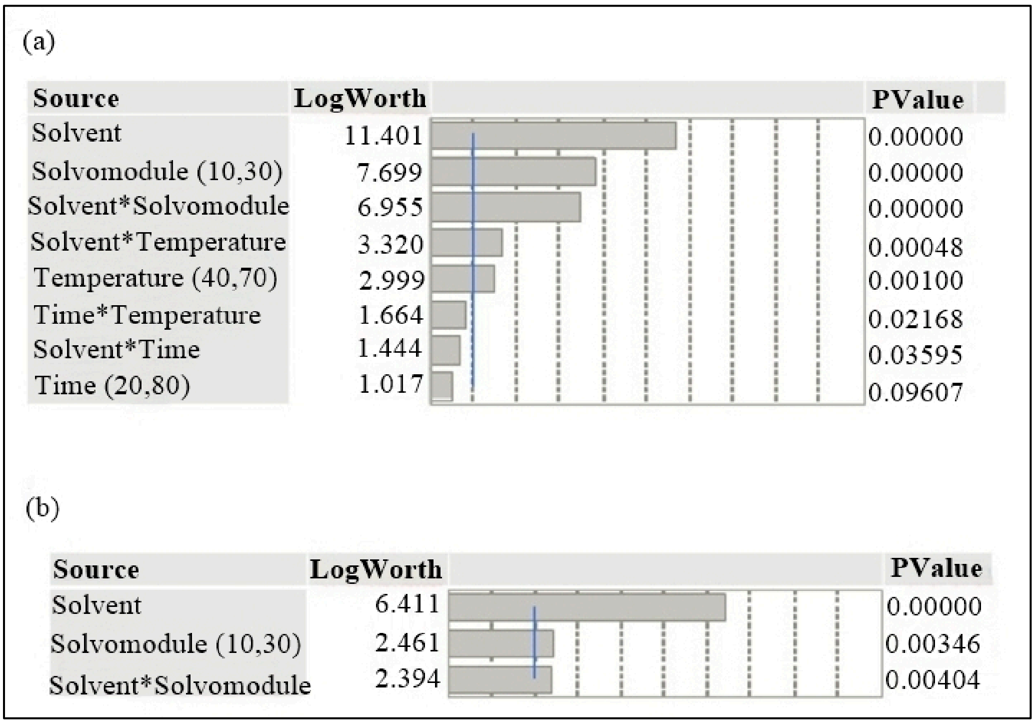

Figure 3. Pereto diagram

The coefficients of the regression model as well as their upper and lower limits with a confidence interval of 95% are given in Table 4. It was observed that hexane has a negative correlation with TEM in comparison to ethanol which has a positive correlation. Regarding the AOA, all studied factors have a positive correlation.

Table 4. The coefficients of the regression model

	Estimate	Std Error	t Ratio	Prob>|t|	Lower 95%	Upper 95%
	Y_1					
Intercept	7.695	0.19659	39.14	<0.0001*	7.2623078	8.1276922
Solvent[Hexane]	-6.185	0.19659	-31.46	<0.0001*	-6.617692	-5.752308
Time (20,80)	0.4	0.219795	1.82	0.0961	-0.083765	0.8837646
Temperature (40,70)	0.975	0.219795	4.44	0.0010*	0.4912354	1.4587646
Solvomodule (10,30)	-3.125	0.219795	-14.22	<0.0001*	-3.608765	-2.641235
Solvent[Hexane]*Time	-0.525	0.219795	-2.39	0.0360*	-1.008765	-0.041235
Solvent[Hexane]*Temperature	-1.075	0.219795	-4.89	0.0005*	-1.558765	-0.591235
Solvent[Hexane]*Solvomodule	2.65	0.219795	12.06	<0.0001*	2.1662354	3.1337646
Time*Temperature	-0.5875	0.219795	-2.67	0.0217*	-1.071265	-0.103735
	Y_2					
Intercept	0.1056684	0.010821	9.77	<0.0001*	0.0827287	0.1286081
Solvent[Hexane]	0.0889738	0.010821	8.22	<0.0001*	0.0660341	0.1119135
Solvomodule (10,30)	0.0414603	0.012098	3.43	0.0035*	0.015813	0.0671077
Solvent[Hexane]*Solvomodule	0.0405691	0.012098	3.35	0.0040*	0.0149217	0.0662164

The model's adequacy was checked by analysis of variance. When it comes to TEM, according to the coefficient of determination (R^2) of 0.98814, ANOVA has shown its adequacy by comparing this value with R^2 Adj. of 0.986597. Therefore, the proposed model well describes the influence of the studied factors on the system response, i.e., TEM. According to statistically imporatant p-value of the model, which is lower than any other significant level (<0.0001), it could be concluded that at least one term in the model explains significant part of TEM variability (Table 4). Regarding the AOA the obtained R^2 value of 0.849898 it could be stated that the model is adequate, but there are some variations in the model that cannot be explained, or there are additional factors that should be taken into account. According to the statistically significant p-value of the model, which is lower than any other significant level (<0.0001), it could be concluded that at least one term in the model explains a significant part of AOA variability (Table 4).

The main factors studied in this paper are shown in Figure 4. The time of extraction has no effect on TEM, while the increase in extraction temperature has a positive effect (confirmed by the coefficient being 0.975 - Table 4). On the other side, the increase in solvomodule decreases TEM (confirmed by the coefficient being -3.125) represented by the sudden fall of the curve (Figure 4). Ethanol has been shown to be a more convenient solvent for TEM since hexane has a negative effect with the coefficient being -6.185 (Table 4). Regarding the AOA, ethanol has also been shown to be a solvent of choice, and the extracts obtained have shown the best antioxidant activity when using solvomodule 1:10 m/V (Figure 4).

To determine the maximum values of TEM, it is necessary to optimize function Desirability (Figure 4). It is estimated that with 95% confidence the main value of the population for TEM will be in the range of 20.62382 - 23.461118 mg/ml, for the following optimal conditions: time of extraction: 80 minutes; extraction temperature: 70 °C; solvomodule: 1:10 m/V and ethanol as solvent. The time of extraction was also considered, although this factor is not statistically significant. Its interaction with other factors was significant. Therefore, the predicted value of TEM was 22.0425 mg/ml. To check the practical applicability of the proposed model, the extraction under the optimal conditions given was performed. The actual, experimentally determined TEM value was 21.20 mg/ml indicating good correlation and the applicability of the regression model to the TEM response. Regarding the AOA the optimal conditions were solvomodule 1:10 m/V and ethanol as solvent. With 95% confidence the mean value of the population for AOA should be in the range of 32.860 to 64.466 μg/ml. Extraction under optimal conditions was performed and the actual EC_{50} value was determined to be 50.7 μg/ml. The predicted value was 15.8 μg/ml. Although these two values differ the actual value is in the predicted range, so the regression model is applicable.

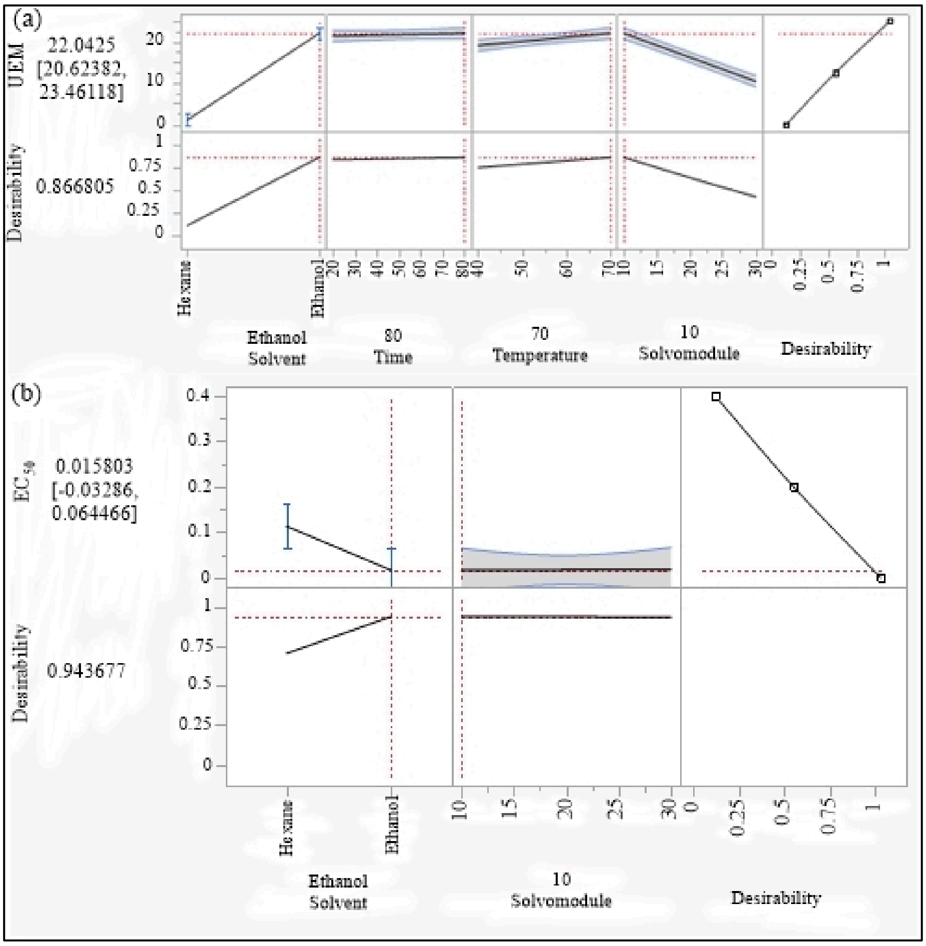

Figure 4. The main factors studied and their effects of (a) TEM and (b) AOA

The factors studied also interact mutually and their synergistic effect influences TEM. Their interactions are shown in Figure 5 where non paralel segments give visual evidence of possible interactions.

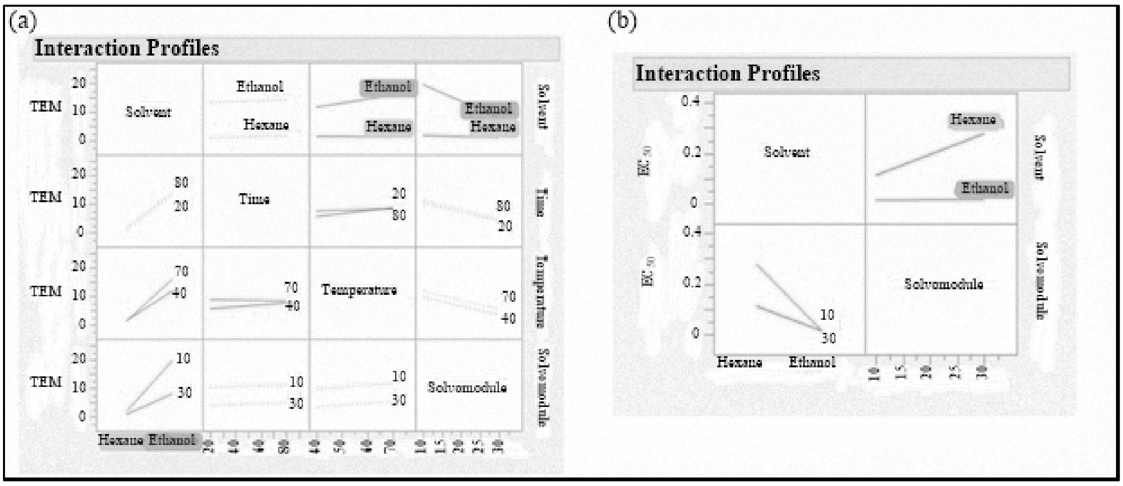

Figure 5. Mutual interactions of the studied factors on (a) TEM and (b) AOA

The three-dimensional diagrams (3D) shown in Figure 6 are given for better visualization of the effects of independent variables on the studied properties (time of extraction and extraction temperature for TEM; solvent and solvomodule for AOA), and also to predict the best values from the target function. With increasing the time and temperature of extraction, TEM increases. On the other side, with increasing the solvomodule, AOA decreases.

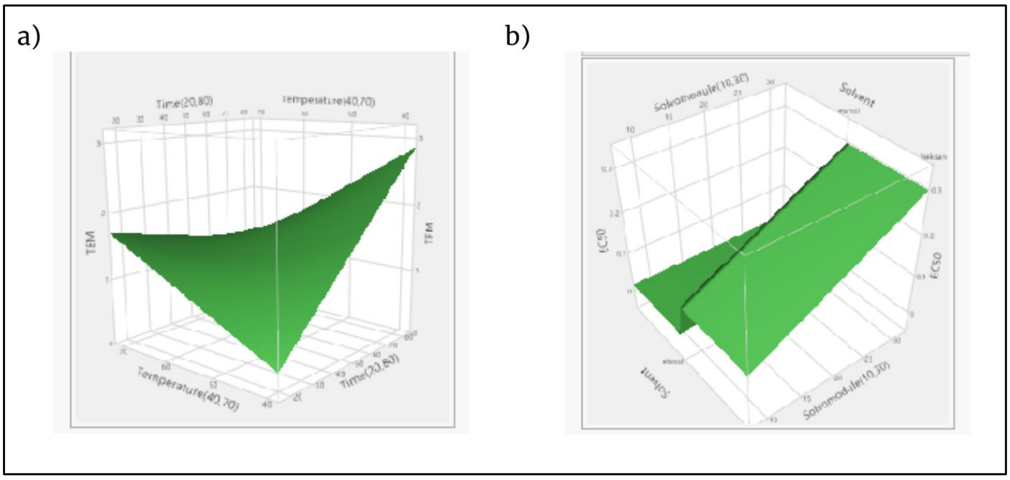

Figure 6. 3D plots show the effect of (a) extraction time and extraction temperature on TEM and (b) solvent and solvomodule on AOA

In conclusion, the findings of this research hold implications not only for industries seeking natural sources of antioxidants but also for researchers exploring alternatives to synthetic dyes. Namely, the ethanolic extract obtained under optimum conditions from *T. patula* L. flower petals grown in Serbia possesses strong antioxidant activity, stronger than synthetic antioxidant butylated hydroxytoluene (BHT) - 0.0507 mg/ml *vs*. 0.43 mg/ml (Stanojević et al., 2022) and could potentially be used in the cosmetic, pharmaceutical, and food industries as a natural alternative.

ACKNOWLEDGEMENTS

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THE USE OF NATURAL DYES IN TEXTILES AND FASHION DESIGN

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ABSTRACT

Synthetic-based dyes are generally used in textile and fashion design due to their easy availability and economy. However, the interest in herbal dyes is increasing day by day due to their health and environmental hazards. Herbal dyes are ecological, biodegradable, anti-allergic, sustainable and sustainable resources. The use of these plant resources is becoming an increasingly important issue day by day. In this study, the use of herbal dyes used in textile and fashion design, the types of herbal dyes used, traditional and commercial dyeing methods, characterization and chemical test analysis methods of herbal dyes and the usage areas of herbal dyes in textile and fashion design are explained. Within the scope of the study, the advantages and disadvantages of the use of herbal dyes, the difficulties experienced and suggestions for their widespread use are included.

Keywords: Herbal Dye, Textile, Fashion

INTRODUCTION

The use of herbal dyes in textile and fashion design is gaining attention day by day, as it is a more environmentally friendly approach than chemical-based dye alternatives. In addition to being an environmentally friendly option, it is a health-sensitive option with high biodegradability, low toxicity, anti-allergenic, sustainability, rich color diversity, adaptability to organic yarns and fabrics, enabling local cultures to survive. Natural dyes derived from plant sources are considered as new agents for imparting multifunctional properties such as antimicrobial, insect repellent, deodorizing and UV protection to textiles (Samatha et al., 2020). In addition to these advantages, in most developing countries of the world, natural dyes are not only a rich and diverse source of dyestuffs, but also a source of income through sustainable harvesting and sale of the plants from which the dyes are derived (Jothi, 2008). Especially in regions where synthetic dyes, mordants (fixatives) and other additives are imported and therefore relatively expensive, natural dyes can offer an attractive alternative (Ghorpadeet et al., 2000).

Herbal dyes can vary in richness depending on the geography used. Within the scope of this study, the types of herbal dyes frequently used in Turkey, the mordanting process, traditional and commercial dyeing methods, characterization and chemical analysis applications of natural dyes, and the usage areas of herbal dyes in textile and fashion design are explained. The aim of this study is to understand the science of natural dyeing in general and at the same time to focus on problem areas, difficulties, possible measures taken to overcome them, and future predictions.

TYPES OF HERBAL DYES USED IN TEXTILE AND FASHION DESIGN

The textile industry consumes large quantities of synthetic dyes such as reactive dyes for dyeing different types of fabrics, especially cotton fabric. The dyeing process requires large quantities of water and as a result large quantities of wastewater are generated a process that creates serious environmental pollution. In many cases, synthetic dyes are known to have properties that are harmful to the environment and human health. In order to get rid of these environmental and health hazards, it is imperative to consider alternatives to synthetic dyes that can make the environment and human health safe. For this reason, herbal dyes are seen as a good solution for the textile industry. There are many natural dyes available in different parts of the world where plants can be used as a complement to synthetic dyes (Guha, 2019). These herbal dyes are attracting more and more attention as part of a sustainable approach.

Turkey is a country rich in plant species due to its geography and climate diversity. According to ethnobotanical studies, Turkey has 1251 genera and more than 12,000 species belonging to 174 families. 234 of these species are of foreign origin and are cultivated plants. The remaining species are plant species that can grow naturally in our country (Kendir and Güvenç, 2010).

Many plants can be used for natural coloring. Some of the frequently used plant species are onion peel (Zubairu and Mashelia), black carrot (Shukla and Vankar, 2013), blueberry (Kayahan, Karaboycı and Dayık, 2016), orange and lemon peels (Kumar and Dhinakaran, 2017), saffron flower petals (Raja et al. 2012), pomegranate peel (Yılmaz and Bahtiyari, 2017), pine tree (Avinc et al., 2010), turmeric (Mozumder and Mozumder, 2016), eggplant peels (Parvinzadeh and Ashrafi, 2009), red pine (Avinc et al. 2013), alder leaves (Eser, 2016). The recycling of the parts of these plants, which are called waste materials, by dyeing method makes natural dyes an important, sustainable and continuous resource with its coloring effect for the textile industry. In their study, Ayvaz and Teker (2023) examined the clothing and accessory businesses that use natural dyeing in Turkey and observed that the number of companies that use natural dyeing is quite limited. They thought that herbal dyeing would increase in the future as a sustainable approach.

TRADITIONAL AND COMMERCIAL HERBAL DYEING METHODS

Samanta and Agarwal (2009) in their study reported the general process in preparing a cotton fabric for traditional natural dyeing, which includes composting, washing, bleaching and steaming, followed by soaking and rinsing in alkaline water. Dyeing of fabric is usually done by boiling with an aqueous extracted solution of special natural dye until all the coloring matter is absorbed by the fabric. The dyed fabric is then washed and left to dry slowly in the air under the sun. To lighten the color, water is sprinkled on the fabric at regular intervals; this process continues for 2-4 days. If the fabric is not dyed sufficiently, finally the fabric is starched by dipping it in rice or wheat flour paste or gum solution and then dried.

The increasing demand of people for environmentally friendly textiles and environmentally friendly natural dyes has led to the development of natural dyeing methods that include newer energy efficient dyeing processes and more repeatable color tone development processes. Scientists working in the field of natural colorant technology are now focusing on improving the extraction of colorant from plant material and its application to surface-modified fabric. In this context, the fabric is penetrated into the surface with different techniques such as UV, microwave or ultrasonic treatment (Sinha et al., 2013).

CHARACTERIZATION AND CHEMICAL ANALYSIS METHODS OF HERBAL DYES

In order to maintain global textile production worldwide, textiles need to be continuously colored. Approximately 700,000 tons of dyes are required, resulting in the release of large amounts of unused and unfixed synthetic colorants into the environment. It is imperative to respond to consumer demand for colorful textiles and fashion products for decoration and aesthetic purposes. It is not possible to dye this high proportion of textile material with natural dyes alone. Therefore, it is also important to use environmentally safe synthetic dyes. However, a certain proportion of colored textiles can always be supported and managed with environmentally friendly natural dyes. In addition, not all natural dyes are environmentally friendly. Natural dyes may contain heavy metals or toxicity. Therefore, natural dyes should be tested for toxicity before use (Samatha and Agarwal, 2009).

Macro and micro chemical analysis to review the chemistry, chemical composition and chemical based classification of natural dyes used, UV-Visible Spectroscopic study of any colorant used, chromatographic analysis to identify different color components in natural dyes to be applied to textiles and any adverse effects of herbal dyes on humans. Toxicity tests are carried out for the possibility of this occurring (Samatha and Agarwal, 2009). In addition, Nuclear Magnetic Resonance Spectroscopy (NMR) to examine the molecular structure of herbal dyes, X-ray Photoelectron Spectroscopy (XPS) to provide surface composition and elemental analysis of herbal dyes, Fourier Transform Infrared Spectroscopy (FTIR) to analyse the molecular structure and chemical groups of herbal dyes. High Performance Liquid Chromatography (HPLC) analysis is performed to separate and identify the components of herbal dyes. In addition to these tests, many durability tests are performed such as washing, rubbing, light fastness tests, pH test, dry cleaning resistance, sweat fastness, chemical exposure test (Yılmaz and Bahtiyari, 2017; Eser, 2016, Khan et al., 2014). These tests can be used to evaluate the quality and color fastness of the fabric after the herbal dyeing process. Test results help manufacturers and consumers understand the performance of herbal dyed fabrics and are decisive for the quality of the product. In addition, these tests are also applied to areas such as consumer safety, works of art and antique restoration.

USES OF HERBAL DYES IN TEXTILE AND FASHION DESIGN

The use of plant-based dyes is common in the food, pharmaceutical, cosmetics and textile dyeing industries. Considering that fashion is a phenomenon that usually changes four times a year, the consumption of chemicals, water and energy used in the production of just one garment is considerable. Limiting this consumption and achieving sustainable products through recycling and upcycling has become the focus of all researchers. Herbal dyes are generally used to dye fabrics made of natural fiber raw materials to create colors, patterns and prints on fabrics.

In addition to the use of natural dyes, natural printing techniques that people have been using since ancient times are also applied in textile fabrics. For example, colorful designs are made with ecological printing, which is the process of coloring textile surfaces with plant materials such as flowers, leaves, etc. in completely natural ways. It should be checked whether the fabric to be ecologically printed is water absorbent, whether it is worked with suitable fibers, and whether pre-finishing processes are carried out with appropriate recipes. It is recommended to apply mordanting process for the dye to be effective and stable. In ecological textile design, even if all conditions are met in the same way, it is not possible to repeat the same color and the same pattern of a product, and for this reason, each product is original, unique and unrepeatable (Bilir, 2018; Figure 1 and Figure 2).

In addition, herbal dyes are also used in textile restoration and antique preparation. They are seen as an important tool used to restore the original colors and appearance of valuable textiles. Herbal dyes to be used in antique and restoration projects should be selected according to the colors and components of the original dyes. Tests should be carried out to examine the colors and textures of the herbal dyes to be used and to capture the right shades.

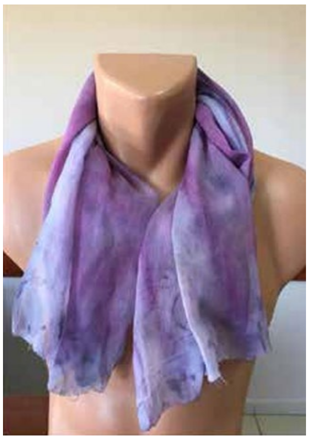

Figure 1. An example of ecological printing using rose, purple carnation and crocus flowers (Bilir, 2018)

Figure 2. Ecological print design using eucalyptus, vine, maple and walnut leaves (Öztürk and Ege, 2019)

Herbal dyeing offers creative designs for designers and the fashion industry in terms of environmental awareness, the possibility of creating a unique color palette, the use of motifs and patterns in historical and cultural contexts, the use of local resources, and the protection of cultural heritage. Many designers and companies want to increase the benefit and recognition of their brands and products by making original designs using herbal dyes. It is predicted that plant-based dyeing will attract more attention in fashion design in the future by offering technological solutions to problems such as mass production difficulties, inability to provide every color tone, lack of chemical auxiliaries, lack of special knowledge and skills.

CONCLUSIONS

Natural dyes derived from plants without chemical treatment are better compatible with the environment and human health due to their non-toxic nature and renewable potential. Today's rapidly changing fashion trends continuously increase resource consumption in the life cycle of textile products. For this reason, textile manufacturers and designers tend towards sustainable, continuous and unique products during and after the production process. Plant dyeing, which provides limited allergy formation, biodegradable, low toxicity, and ensures the transfer of cultural heritage, is becoming more and more the center of attention day by day. Natural dyes derived from plant sources are capable of imparting many properties to textile products such as antimicrobial, insect repellent, deodorizing and UV protection (Samatha et al., 2020). Despite some disadvantages such as color constancy, incompatibility, long production processes, supply of chemical auxiliaries, traditional and commercial herbal dyeing methods are frequently used. Turkey is in an advantageous position for plant dyeing due to its geography and climate, which harbours many plant species. As a result, with the research of various plant species, the development of new technologies and the use of methods, the work of designers, manufacturers and researchers in this field will increase and sustainable herbal dyeing will continue in the future.

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INVESTIGATING THE ANTIMICROBIAL EFFECT OF THE DYESTUFF OBTAINED FROM *RUBIA TINCTORUM* L.

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ABSTRACT

Products obtained from plants have many uses. This richness of plants is an important source for dyes as well as for the pharmaceutical, cosmetics and food industries. Root dye (*Rubia tinctorum* L.), which is one of the 40 species belonging to the Rubia genus from the 450 genera of the Rubiaceae family, has always been a current issue for researchers as it contains 20 types of anthraquinone pigments in its structure. Anthraquinones have also been included in the literature with their antifungal, antimalarial, antileishmanial and antioxidant effects.

Antimicrobial textile products are used to prevent infections caused by microorganisms, to keep infections under control, to prevent odor and color change caused by microorganisms, and to prevent quality loss. Our study aimed to determine the degree of antimicrobial activity of the dye obtained from the Rubia tinctorum L. plant. Antimicrobial activity tests were carried out in accordance with the AATCC 100 test method and the Turkish Standards Institute TS EN 1040/1999 test method recommendations. This method is a quantitative method, and after the liquids containing microorganisms are absorbed onto the sample fabrics, the change in the number of microorganisms in the environment is proportionally converted into antibacterial activity data. The decrease in the amount of microorganisms compared to the initial amount was determined as R(%). When the R value was calculated, significant activity was detected against the gram-negative bacteria E. coli in the dyed-aerated fabric samples, and against the gram-positive bacteria *S. aureus* ATCC 6538 in the silk and felt dyed fabric samples. The highest activity in dyed-silk fabric samples was observed on *S. epidermidis* NCTC 11047, a gram-positive bacterium.

It was observed that felt did not absorb the liquid sufficiently from the fabric samples and some values could not be determined in the gauze samples due to their chemical substance content. The results obtained from the silk fabric sample are thought to be more reliable. In addition, moisture, organic matter, etc., especially in the environment such as fabric. The occurrence of different conditions will also affect antimicrobial effectiveness. For this reason, it is recommended that dyestuffs with an effective effect be tested in real life conditions.

Keywords: Antimicrobial activity, natural dye, *Rubia tinctorum L.*, dyeing

INTRODUCTION

Products obtained from plants have many uses. This richness of plants is an important source for dyes as well as for the pharmaceutical, cosmetics and food industries. It is also known that some substances obtained from plants have antimicrobial activity. These substances are used in textile products to help reduce and eliminate the negative effects caused by microorganisms.

Antimicrobial textile products are used to prevent infections caused by microorganisms, to keep infections under control, to prevent odor and color change caused by microorganisms, and to prevent quality loss (Palamutcu et al., 2009).

Root dye (*Rubia tinctorum* L.), which is one of the 40 species belonging to the Rubia genus from the 450 genera of the Rubiaceae family, has always been a current issue for researchers as it contains 20 types of anthraquinone pigments in its structure.

Anthraquinones are compounds containing carbonyl groups that can be derived from benzene, aromatic ring groups and fused polyring systems and are named accordingly, and are used in the pharmaceutical-pharmaceutical, dye-chemical and food industries (Duval et al., 2016). Anthraquinones consist of a keto group at position 9,10 as the basic nucleus and an anthracene ring located in various positions with different functional groups such as -OH, -CH3, -OCH3, -CH2OH, -CHO, -COOH and so on (Fouillaud et al., 2016). Anthraquinones and their derivatives are found in reduced and glycoside form in plants, mosses, lichens, fungi, marine animals and algae (Diaz et al., 2018). Anthraquinones are free or in the form of glycosides in the root shoots of Rubia species (Harmancıoglu, 1955).

Antriconones have also been included in the literature with their antifungal (Wuthiudomlert et al., 2010), antimalarial (Winter et al., 1996), antileishmanial (Dimmer et al., 2023) and antioxidant (Dave et al., 2012) effects. Some components found in the roots and rhizomes of Rubia tinctorum L., such as di- and tri-hydroxyanthraquinones, alizarin, purpurin and their derivatives, ruberitric acid, pseudopurpurin, have important roles in the therapeutic properties of this plant (Nartop, 2018).

The chemical formula of Alizarin is C14H8O4 and its molecular weight is 240.20 g. Its melting point is 289-290 0C and its boiling point is 430 0C. It is in the form of a red, needle-shaped or crystal-shaped yellowish and brown powder. Alizarin does not dissolve easily in water. It is also soluble in ethanol, ether, acidic acid, xelol and carbon sulfide. The maximum absorptions of alizarin in ethanol are 247, 278, 330 and 434 nm. It gives purple-blue color at high pH, purple-red color at low alkalinity, and yellow-orange color at low pH (Harmancıoğlu, 1955).

Alizarin has also been proven to exhibit various biological activities (antimicrobial, antioxidant, anti-leukemia, anti-HIV and antitumor activities) (Singh et al., 2005; Kharlamova 2009; Deng et al., 2006).

In the methods used to detect antimicrobial activity; the concentration of the substance, time of exposure and inoculum of the microorganism are important. Since the minimum inhibition concentration and half-life of the antibiotic are important in determining the effects of antibiotics, diffusion and dilution methods are used. However, diffusion and dilution methods are insufficient since contact time is also very effective on the antimicrobial activity of substances such as disinfectants and dyes. For this reason, disinfectant activity tests are used to determine the degree of antimicrobial activity. In these tests, the decrease in the amount of microorganisms compared to the initial amount is expressed as R(%). These methods are quantitative methods, and in the method, the change in the number of microorganisms in the environment is proportionally converted into antimicrobial activity data.

MATERIAL AND METHOD

In this study it was aimed to determine the degree of antimicrobial activity of the dyestuff obtained from Rubia tinctorum L. and the study was carried out in accordance with the AATCC 100 test method and the Turkish Standards Institute TS EN 1040/1999 test method recommendations.

Silk, felt and gauze fabric samples were prepared including a fabric control sample containing no dyes and a fabric control sample prepared with an antibiotic with known antimicrobial activity for each microorganism were used for quality control purposes. *Pseudomonas aeruginosa* ATCC 15442, *Escherichia coli* ATCC 11229, *Klebsiella pneumoniae* ATCC 4352, *Staphylococcus aureus* ATCC 6538, *Staphylococcus aureus* ATCC 29213, *Staphylococcus epidermidis* NCTC 11047 and *Candida albicans* ATCC 10231 standard strains were included in the study. Fabric samples contaminated with microorganism suspensions were kept for 8 hours and then placed in neutralizing liquid medium to stop the antimicrobial effect of the dye and passaged to agar plates. Samples containing bacteria were incubated at 37 °C for 24 hours, and samples containing yeast were incubated at 35 °C for 48 hours. After incubation, colonies grown on agar plates were counted. The decrease in the amount of microorganisms compared to the initial amount was determined as R(%). This value indicates that antimicrobial activity is sufficient for disinfection when it is greater than 99% or a decrease of approximately 3 log CFU/mL was observed.

$$R(\%) = 100\,(B-A)/B$$

Here,

R = proportional decrease

B = number of organisms in the solution that were in contact with the sample at the initial time

A = number of organisms in the neutralization solution that have come into contact with the sample

Table 1. Colony numbers (CFU/mL) in contaminated silk fabric samples under different conditions

	STARTING INOCULUM	DYED FABRIC	UNDYED FABRIC
Pseudomonas aeruginosa ATCC 15442	$0{,}1x10^6$CFU/mL	$0{,}1x10^5$CFU/mL	$0{,}1x10^6$CFU/mL
E. coli ATCC 11229	$0{,}5x10^6$CFU/mL	$0{,}4x10^5$CFU/mL	$0{,}1x10^6$CFU/mL
Klebsiella pneumoniae ATCC 4352	$0{,}1x10^6$CFU/mL	$0{,}2x10^5$CFU/mL	$0{,}5x10^6$CFU/mL
Staphylococcus aureus ATCC 6538	$0{,}1x10^5$CFU/mL	$0{,}3x10^3$CFU/mL	$0{,}2x10^5$CFU/mL
Staphylococcus aureus ATCC 29213	$0{,}1x10^6$CFU/mL	$0{,}2x10^5$CFU/mL	$0{,}2x10^6$CFU/mL
S. epidermidis NCTC 11047	$0{,}1x10^5$CFU/mL	$0{,}4x10^3$CFU/mL	$0{,}5x10^5$CFU/mL
Candida albicans ATCC 10231	$0{,}8x10^5$CFU/mL	$0{,}45x10^4$CFU/mL	$0{,}3x10^5$CFU/mL

Table 2. Colony numbers (CFU/mL) in contaminated felt fabric samples under different conditions

	STARTING INOCULUM	DYED FABRIC	UNDYED FABRIC
Pseudomonas aeruginosa ATCC 15442	$0{,}1x10^6$CFU/mL	$0{,}2\ x10^5$CFU/mL	$0{,}1\ x10^6$CFU/mL
E. coli ATCC 11229	$0{,}5x10^6$CFU/mL	$0{,}72\ x10^4$CFU/mL	$0{,}1\ x10^6$CFU/mL
Klebsiella pneumoniae ATCC 4352	$0{,}1x10^6$CFU/mL	$0{,}3\ x10^5$CFU/mL	$0{,}4\ x10^6$CFU/mL
Staphylococcus aureus ATCC 6538	$0{,}1x10^5$CFU/mL	$0{,}1\ x10^4$CFU/mL	$0{,}4\ x10^5$CFU/mL
Staphylococcus aureus ATCC 29213	$0{,}1x10^6$CFU/mL	$0{,}1\ x10^5$CFU/mL	$0{,}1\ x10^6$CFU/mL
S. epidermidis NCTC 11047	$0{,}1x10^5$CFU/mL	$0{,}2\ x10^4$CFU/mL	$0{,}2\ x10^5$CFU/mL
Candida albicans ATCC 10231	$0{,}8x10^5$CFU/mL	$0{,}3\ x10^4$CFU/mL	$0{,}3\ x10^5$CFU/mL

Table 3. Colony numbers (CFU/mL) in contaminated gauze fabric samples under different conditions

	STARTING INOCULUM	DYED FABRIC	UNDYED FABRIC
Pseudomonas aeruginosa ATCC 15442	$0{,}1x10^6$CFU/mL	$0{,}2\ x10^5$CFU/mL	$0{,}1\ x10^5$CFU/mL
E. coli ATCC 11229	$0{,}5x10^6$CFU/mL	$0{,}5\ x10^4$CFU/mL	$0{,}9\ x10^5$CFU/mL
Klebsiella pneumoniae ATCC 4352	$0{,}1x10^6$CFU/mL	$0{,}2\ x10^5$CFU/mL	$0{,}2\ x10^4$CFU/mL
Staphylococcus aureus ATCC 6538	$0{,}1x10^5$CFU/mL	$0{,}2\ x10^4$CFU/mL	$0{,}2\ x10^4$CFU/mL
Staphylococcus aureus ATCC 29213	$0{,}1x10^6$CFU/mL	$0{,}1\ x10^5$CFU/mL	$0{,}6\ x10^4$CFU/mL
S. epidermidis NCTC 11047	$0{,}1x10^5$CFU/mL	$0{,}9\ x10^3$CFU/mL	$0{,}1\ x10^4$CFU/mL
Candida albicans ATCC 10231	$0{,}8x10^5$CFU/mL	$0{,}1\ x10^4$CFU/mL	$0{,}2\ x10^4$CFU/mL

Table 4. R (%) values of the antimicrobial effect detected in dyed fabric samples versus the initial inoculum

	Gram negative bacteria			Gram positive bacteria			Yeast
	P. aeruginosa ATCC 15442	*E. coli* ATCC 11229	*K. pneumoniae* ATCC 4352	*S. aureus* ATCC 6538	*S. aureus* ATCC 29213	*S. epidermidis* NCTC 11047	*C. albicans* ATCC 10231
Silk	90	92	80	99,7	80	96	94,3
Felt	80	98,56	70	99	90	80	96,25
Gaseous	80	99	80	98	90	91	98,75

Table 5. R (%) values of the antimicrobial effect detected in dyed fabric samples versus undyed fabric samples

	Gram negative bacteria			Gram positive bacteria			Yeast
	P. aeruginosa ATCC 15442	*E. coli* ATCC 11229	*K. pneumoniae* ATCC 4352	*S. aureus* ATCC 6538	*S. aureus* ATCC 29213	*S. epidermidis* NCTC 11047	*C. albicans* ATCC 10231
Silk	90	60	96	98,5	90	99,2	85
Felt	80	92,8	92,5	97,5	90	90	90
Gaseous	30	91,1	50	50	NE*	NE*	50

*Not evaulated

RESULTS

Textile materials have an important role in human life and can be in constant contact with the human body. For this reason, the properties of textile materials also affect our comfort. In this context, antimicrobial textiles have begun to attract attention. This study was aimed to determine the degree of antimicrobial activity of the dyestuff used in a textile product.

Şapcı et al. (2017) stated that substances obtained from madder dye show higher activity on bacterial species of fabrics dyed with *Viburnum opulus* juice, while onion peel has a greater effect on yeast. It was stated that *Viburnum opulus* showed the highest activity on *E. coli*, while onion peels showed the highest activity on *C. albicans*.

Alizarin has also been proven to exhibit various biological activities (antimicrobial, antioxidant, anti-leukemia, anti-HIV and antitumor activities) (Singh et al., 2005; Kharlamova 2009; Deng et al., 2006). Studies show that alizarin at 10 μg/ml is a non-toxic biofilm inhibitor that significantly inhibits biofilm formation and hemolytic activity of *S. aureus* (Lee et al., 2016).

To examine its effect as an antimicrobial agent, ethanol, methanol, ethyl acetate and water extracts of *Rubia tinctorum* L. were tested by the disk diffusion method. As a result, it antimicrobial activity against some Gram (+) and Gram (-) bacteria, yeasts, filamentous fungi and actinomycetes was determined (Kalyoncu et al., 2006).

According to the findings obtained in our study (Table 1, Table 2, Table 3), a decrease in the number of microorganisms was observed in dyed fabric samples compared to undyed fabric samples. This finding is consistent with studies detecting antimicrobial activity.

Although all reduction rates are important in terms of showing antimicrobial activity, the R value must be calculated and be greater than 99% in order to evaluate the antiseptic or disinfectant activity of the paint. When the R value was calculated, significant activity was detected against *E. coli* in the dyed-aerated fabric samples, and against *S. aureus* ATCC 6538 in the silk and felt dyed fabric samples. The highest activity in dyed-silk fabric samples was observed on *S. epidermidis* NCTC 11047, a gram-positive bacterium belonging in human skin microbiota.

During the study, it was observed that felt fabric did not absorb the liquid sufficiently. Also, some values could not be determined in the gauze samples due to the chemical substance content itself. The results obtained from the silk fabric sample are thought to be more reliable. In addition; the occurrence of different conditions like moisture, organic matter, chemicals etc., will also affect antimicrobial effectiveness. For this reason, it is recommended that dyestuffs with antimicrobial effect to be tested in real life conditions for further studies.

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CHARACTERIZATION OF POWDER PIGMENT USED IN THE PRODUCTION OF EDIRNE RED AND CIE L*A*B* SYSTEM COORDINATES OF APPLICATIONS ON DIFFERENT SURFACES

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ABSTRACT

Colors have a significant psychological and emotional influence on several aspects of human existence. In addition to their beneficial effects on humanity, colors have a substantial impact on culture and tourism. They also have an important role in urban tourism since they serve to differentiate a city from others, so establishing a distinct "city identity".

The province of Edirne boasts a wealth of cultural and touristic aspects that have contributed to its historical significance and prosperity. The artifact known as Edirne red, although it has been neglected and overlooked throughout history, holds significance within its context. The color referred to as Edirne, which falls within the red spectrum, is derived from the Rubia tinctorum L. plant through the process of natural dye production. The presence of this color has great importance in terms of city history and cultural heritage. Hence, it is an issue that needs to be emphasized both from a cultural and scientific perspective.

The CIE L*a*b* color system, one of the fundamentals of color science, is a mathematical system created by the International Commission on Illumination (CIE) in 1976 and used to determine the coordinates of a color in a color space.

Within the scope of this study, natural dye powder and dyed surfaces such as fabric and yarn are provided by Trakya University. CIE L*a*b* coordinates of sample of dye powder and applied surfaces are determined, and color characterization was performed by using spectrophotometer. In addition, various instrumental analyzes were carried out for the chemical characterization of the natural dye powder. To conduct the characterization of the Edirne red powder dye, a diffractogram was acquired using an X-ray diffractometer (XRD), with measurements taken within the

range of 5-70°. Due to its origin from a natural source there was a hypothesis that the material would include an organic structure. Consequently, an analysis was conducted using the Attenuated Total Reflectance (ATR) module on the Fourier Transform Infrared (FTIR) device, and the resulting spectra were evaluated. The determination of thermal resistance performance was conducted using the Differential Thermal Analysis (DTA) equipment, as organic structures have the potential to undergo decomposition when exposed to elevated temperatures.

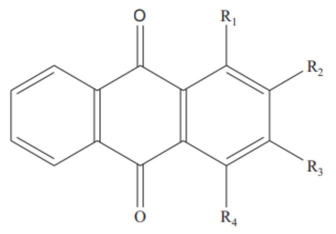
Keywords: Edirne Red, CIE L*a*b* System, Color space, Natural dye, Characterization

INTRODUCTION

Colors have been a subject of academic and practical interest for many years due to their psychological and emotional effects on various aspects of human existence. The first pigments obtained using natural sources formed the basis of paint. With subsequent technological developments and discoveries, scientists have identified lots of colors (Yu et al., 2020). In addition to the positive effects of colors on people, they also have significant effects on culture and tourism. They also have an important role in urban tourism since they serve to differentiate a city from others, so establishing a distinct "city identity" (Akman,2021).

The city of Edirne, which has been a home to many historical and cultural heritage, contains a wide variety of touristic aspects. Edirne red, also named as "Rouge d'Andrinople" in French, obtained through the natural dye production process from the Rubia tinctorum L. plant, is one of these touristic aspects. Edirne red, is not only a color but also a cultural element dating back to the Ottoman Empire. However, with the development of technology after the industrial revolution, it began to be forgotten (Akman, 2021). Therefore, studies on the subject have a socio-cultural impact as well as a scientific impact.

The plant species used to obtain the Edirne red color is Rubia tinctorum found in the Mediterranean basin (tinctorial madder). The structure of the dyestuff constituents consists of molecules with an anthraquinone or similar skeleton. Figure 1a shows the skeleton structure of this molecule. The plant initially biosynthesis precursor dyes, which are heterosidic compounds. Subsequently, these compounds undergo intensive enzymatic hydrolysis, bond breaks between glycosides and anthraquinones occur and aglycone dyes are released. The main aglycone compounds are alizarin, purpurin, lucidin, rubiadin and pseudopurpurin (Cuoco, 2011). The chemical structures of some anthraquinone-based dyes found in R. tinctorum are shown in Figure 1b.



Alizarin	R1=OH, R2=OH, R3=H, R4=H
Purpurin	R1=OH, R2=OH, R3=H, R4=OH
Lucidin	R1=OH, R2=CH2OH, R3=OH, R4=H
Rubiadin	R1=OH, R2=CH3, R3=OH, R4=H
Ruberythric acid	R1=OH, R2=O-primeveroside, R3=H, R4=H

Figure 1.a. The skeleton structure of anthraquinone molecules; b. The chemical structures of some anthraquinone-based dyes (Cuoco, 2011)

It is important to know the chemical structure of dyes obtained from plants and to determine their color characterization for further studies. For this reason, various analysis methods are used to determine the content of the natural powder dye. X-ray diffractometer (XRD) used to determine the crystal structure, Fourier Transform Infrared (FTIR) used to determine the molecular structure and Differential Thermal Analysis (DTA) used to determine the thermal properties are some examples of analysis methods used in this study and in chemical property characterization in general.

Color characterization for dyestuffs is critical for obtaining final product. For color characterization and measurement, a method called CIELAB is used, which was established by the International Commission on Illumination (CIE) in 1976. The values used in this method are determined as L*a*b* and their explanations are as follows,

L* value represents the between light (where L*=100) and dark (where L*= 0),

a* value represents the between green (-a*) and red (+a*)

b* value represents the between yellow (+b*) and blue (-b*) (Cuoco, 2011).

Within the scope of this study, chemical characterization of natural dye powder was carried out. Moreover, CIE L*a*b* coordinates of dye powder and applied surfaces were determined. All samples were provided by Trakya University. Color characterization was performed by using a spectrophotometer. Pigment obtained from Rubia tinctorum, was characterized performing a multi-technique analytical study by integrating X-ray diffractometer (XRD), Fourier Transform Infrared (FTIR)-Attenuated Total Reflectance (ATR) module, Differential Thermal Analysis (DTA).

MATERIALS AND METHODS

Natural dye powder and painted surfaces such as fabric and yarn used in the study were supplied from Trakya University.

Chemical characterization of the natural dye powder

The crystalline phases were characterized via XRD using a Philips PANalytical X'Pert-Pro X-ray diffractometer with CuKα radiation using the operating parameters of 40 mA and 30 kV with a step size of 0.02^{o} over the scanning range 2λ = 5–70^{o} for powder dye sample.

FTIR analysis was performed using a spectrometer (Perkin Elmer Spectrum 100 (United States) Series) in reflection mode using a diamond crystal attenuated total reflectance (ATR) sliding fixture in order to determinechemical bond structures and chemical groups attached to the powder dye molecules. The spectral range is 4000-600 cm^{-1}, and the resolution is 4 cm^{-1}.

The weight loss process of the material was recorded on a TA Instruments-Waters LLC Discovery Series-Model 650, Simultaneous Thermal Analyzer (STA), under Ar atmosphere (10 mL min^{-1}) and a heating rate of 10 °C min^{-1}, between 25-1200 °C.

Color characterization of the natural dye powder

CIE L*a*b* coordinates of sample of dye powder and applied surfaces (fabric and yarn) are determined, and color characterization was performed by using X-Rite SP-64 spectrophotometer.

Data are reported in the CIE L*a*b* colorimetric system. L* values represent lightness on a 0 (pure black) to 100 (pure white) unit scale, a* values range from –60 (pure green) to +60 (pure red), and b* values range from –60 (pure blue) to +60 (pure yellow). Each sample was analyzed three times (Cuoco, 2011).

RESULTS AND DISCUSSION

Chemical characterization results of the natural dye powder

XRD analysis was performed to determine the crystal structure of natural pigment. The XRD diffraction pattern is given in Figure 2.

When the XRD results are examined, sucrose structure is seen in the sample. It is known that sucrose which is called a type of sugar, has a crystalline structure (Güldane, 2014). Due to the vegetable origin of the dye powder, it is expected to analyze this structure in the content. Since no other crystalline peaks were observed in the diffractogram it was concluded that the other substances contained in the powder dye sample were obtained from *Rubia tinctorum* L.

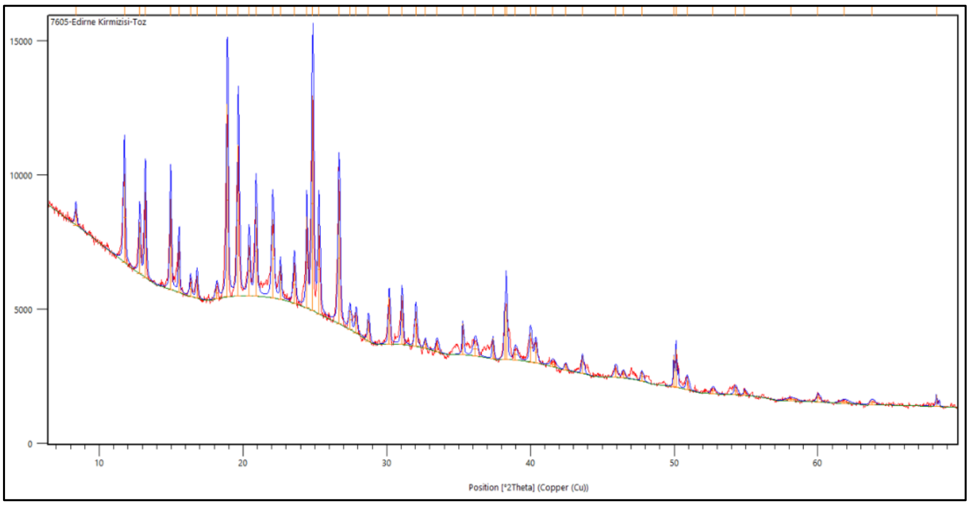


Figure 2. XRD pattern of Edirne red powder dyeFT-IR spectrum of sample is given in Figure 3. The main adsorption bands detected as results of FT-IR analysis are also listed in Table 1.

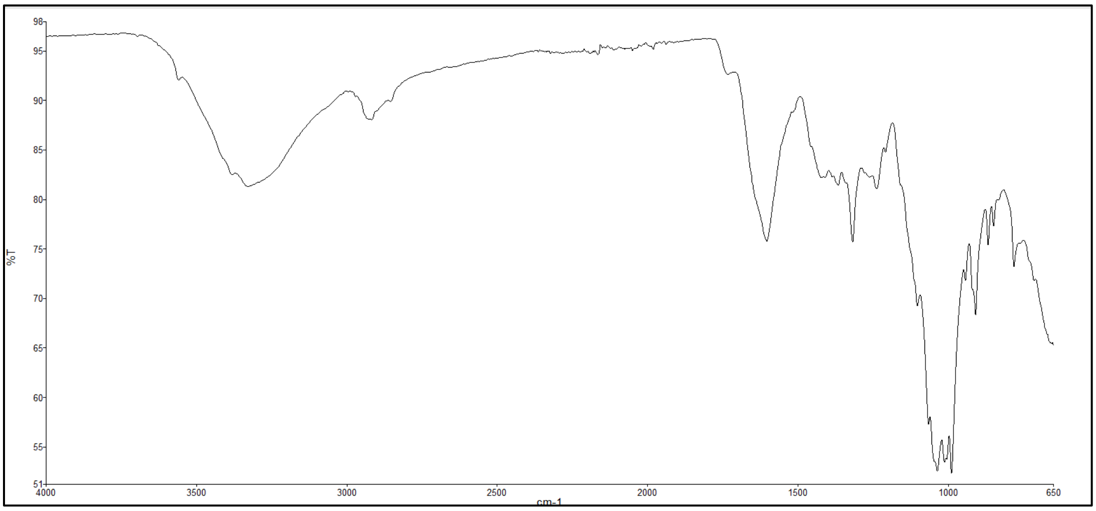


Figure 3. FT-IR spectrum of Edirne red powder dye

Table 1. Main bands in the infrared spectra of natural dye powder sample

Peak number	Wavelenght (cm^{-1})
1	3329
2	2916
3	1603
4	1318
5	1238
6	1036
7	1012
8	989
9	908
10	867
11	849
12	781

Intense absorption band in the IR spectra in the region of 3329 cm^{-1} is due to stretching O–H groups (cellulose). The peak at about 2916 cm^{-1} is attributed to the =C–H aromatic ring groups of anthraquinonic structures. The bands can be identified at 1603 cm^{-1} as phenyl ring (aromatic skeletal vibration) >C=C< in anthraquinones, at 1318 cm^{-1} as C–H in plane bending, at 1238 cm^{-1} as C–O stretching, at 1037 cm^{-1} as

C–O–C stretching vibration (Langa-Nomba et al., 2021; Ghandehari et al. 2019; Pronti et al. 2018). The band at 989 cm^{-1} indicates the aromatic C–H in-plane bending.

The DSC analysis results performed to determine the thermal properties of the sample are given in Figure 4.

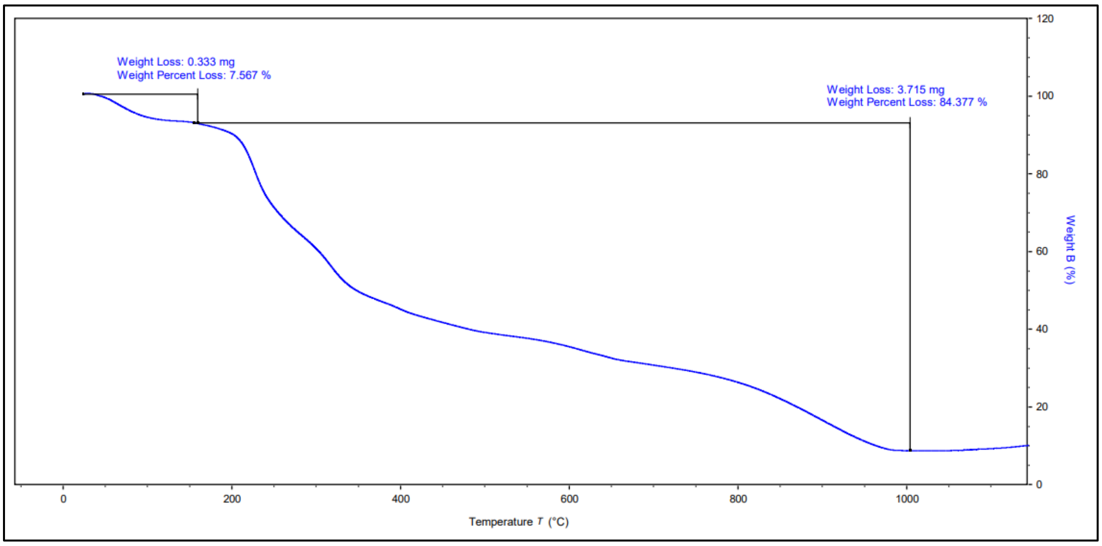


Figure 4. DSC analysis graphic of Edirne red powder dye

When the results are examined, it is seen that there is basically a two-stage mass loss in the structure. It is thought that the mass loss up to approximately 200 ºC is due to moisture and water in the structure. The mass loss that occurred in the second stage did not occur in gradual steps. This can be explained by the fact that the decomposition temperatures of the organic compounds in the structure are very close to each other. According to the DTA analysis results, it is seen that the structure begins to decompose after 200 ºC. For this reason, the application conditions using this natural dye should not be higher than 200 ºC.

Color characterization results of the natural dye powder

Color coordinates of samples (dye powder, fabric and yarn) was measured, in CIE L*a*b* system, with a spectrophotometer. The L*a*b* values, repeated 3 times for each sample are given in Table 2.

Table 2. The L*a*b* values of the samples

Measurement Times	Dye powder			Fabric			Yarn		
	L	a	b	L	a	b	L	a	b
1	50.93	12.39	15.14	37.63	37.04	25.03	39.24	33.56	28.86
2	50.35	12.60	15.60	38.20	37.50	25.82	37.94	33.71	28.97
3	49.27	13.04	15.70	37.69	37.50	24.88	37.80	32.89	27.38
Mean Value	50.18	12.68	15.48	37.84	37.35	25.24	38.33	33.39	28.40

In CIE- L*a*b* system L* value represents the lightness of the samples and (a*) and (b*) values represent red and yellow colors respectively in the positive direction. The mean (L*) values vary from maximum 50.18 (dye powder) to minimum 37.84 (fabric sample). The decrease of (L*) values after dying shows that fabric and applied samples tend more toward pure black than dye powder. Due to the (a*) and (b*) values of all measured samples are positive, they were evaluated only in red and yellow directions. When the samples were compared, it was seen that these values of the dyed fabric and thread samples were higher than dye powder. The redness and yellowness intensity on both applied surfaces is higher than powder paint and shows differences in each other. It is thought that the color deviation results from different application techniques and different surface structures.

CONCLUSION

The study focused on examining the characterisation of the color and chemical structure of the Edirne red pigment. The numerical definition of color holds significance in fostering long-term unity, both within academic and commercial contexts.

The characterisation investigation involved the utilization of XRD, FTIR, and DTA techniques. The XRD investigation revealed the presence of an amorphous diffractogram, which can be attributed to the organic nature of the sample. Additionally, the crystalline phase detected in the diffractogram was identified as a derivative of sugar. The FTIR study successfully identified the presence of bonds within the material's structure. The primary finding of the DTA indicated that the material exhibited decomposition at a temperature of 200 °C, which can be attributed to its organic composition. Furthermore, it was seen that the material's application at temperatures exceeding this threshold was not feasible.

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USE OF VARIOUS NATURAL PLANT EXTRACTS IN TEXTILE PRINTING

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ABSTRACT

Textile and fashion supply chain, the use of natural materials, transition to zero carbon and zero waste are the trending topics of recent years. In this context, the return to fabric colouring with natural dyes is becoming increasingly common. In this experimental work, organic cotton fabrics were printed with some natural dyes such as indigo, *Terminalia chebula*, *Onion skin, Morus alba* and *Tagetes erecta.* Selected colours were applied to the design pattern via screen printing. Colour differences, fastness properties and printing durability of printed samples were investigated. Finally, acceptable colours and adequate colour fastness results were obtained after printing organic cotton.

Keywords: natural printing, natural dyes, organic cotton, sustanability

INTRODUCTION

Plant, animal and mineral based natural dyes have been used as colourants in various areas throughouth history. Dyeing of different textile fibers with natural dyes according to today's technology is one of the trending topics in recent years.

Indigo dyeing on wool can be used by combination with other natural dyes in one-bath process as a hybrid dyeing concept. The fact that indigo allows hybrid dyeing provides significant savings in energy and time (Komboonchoo et al., 2009).

In an another study, silk and cotton textiles were dyed with indigo and their fastness properties were examined. After coloring cotton with indigo, clothes with richer colours than silk were produced. It is thought that the research results will be beneficial for effective use, especialy in products with local identity (Chaiai et al., 2003).

Terminalia Chebula obtained from the fruit of a plant was used in dyeing the wool textiles. It was used as an enviromental friendly natural colourant for sustainable textile colouration of woolen yarn. Iron sulphate, alum and tin II chloride metalic mordants were used during dyeing process. Medium light fastness test results were obtained in dyeings in which iron sulphate and alum were used as mordants (Shabbir et al., 2016).

A process has been developed for printing on cotton fabric with *Terminalia chebula*. Effects of different metal mordants on shades in terms of colour strenght (K/S) was investigated. It has been reported that fabrics printed with natural dyes in soft and subdued shades can be used commercially (Patel et al., 2009).

Although onion is mostly used for dyeing in literature, it has recently been used to colour fabric by printing. Linen and tencel fabrics were eco-printed with onion skin and red cabbage in a research work. Colour and fastness properties of the printed materials were compared. The printing method and natural dyes were presented as suggestions for producing creative and sustainable textile patterns (Bruna et al., 2022).

Cotton fabrics were dyed with conventional and sonication methods with *Morus alba* L. by Ohama. The leaves extract to provided brown-green to green colour, depending on the different pH values. The sonication was rather effective than conventional method at low temperature and short time (Ohama, 2014).

Tagetes erecta is a stout branching herb extensively cultivated in all over India. The flowers mainly contain the flavonol-quercetagetol, which is a derivative of querceto. In another research study, printing on hand-woven cotton fabric with te above herbal colourants (one of them was *Tagetes erecta*) in the presence of different inorganic salts such as alum, iron and copper sulphate and evaluating the different colour fastness properties of these printed samples. Printed textiles with *Tagetes erecta* had acceptable colour fastness test results (Maulik et al., 2020).

In this experimental research, a designed pattern was printed with more than one natural dye in industrial conditions and its performance was evaluated. Colour yield, fastness properties and printing durability of printed organic cotton fabrics were tested and the results wete discussed.

MATERIALS AND METHODS

Fabric, Natural Dyes and Chemicals

In this experimental work, 100% organic cotton 30/1 knitted fabric, ready for printing, was used. The weight of the fabric was 140 gm^{-2}.

Indigoteria, *Terminelia chebula* 'a' and 'b', *Onion skin*, *Morus alba* L. and *Tageres eracta* were obtained from Colorkim Chemistry (Turkey). The following standard chemicals which used on printing paste were obtained from commercial sources.

Printing Method

Designers within Toraman Design Centre created fabric pattern designs using Adobe Photoshop CS6 Software. The designers were inspired by nature, and they designed fabric patterns to be used in baby and children's clothing. Among these designs, the pattern chosen to be used in the study is shown in Figure 1.

Figure 1. Design chosen for applications

Target colours were selected from the Pantone Catalogue. The target colours that can be obtained with natural dyes (Indigoteria, Terminelia Chebula ‘a’ and ‘b’, *Onion skin*, *Morus alba*, and *Tageres eracta*) are as follows: Pantone 19-3918 TPG (periscope), 12-0712 TPX (vanilla), 17-1225 TPG (tawny birch), 16-0220 TPX (mistletoe), 16-0924 (croissant) and 13-0720 TPG (custard).

The printing paste was contained ludigol (12.5 g), bicarbonate (30 g), iron sulphate (40 g), urea (200 g), thickener (15.5 g), natural dye (x g) and water. Viscosity of pastes were 40-45 dPas. All prints were made according to the Silk Screen Printing Technique. Afterwards, the printed fabrics were dried at 100-110 °C and steamed at 102 °C. After steaming, the fabrics were washed at 40 °C for 15 minutes and dried at 120 °C.

Colour Measurement

The reflectance values of printed fabrics measured using an X-rite spectrophotometer. The CIEL*a*b* values were calculated using illuminant D_{65} and 10° standard observer values. From the reflectance values in the visible spectrum at the maxsimum absorption wavelenght for each printed colour.The $CMC_{2:1}$ Color Differences Formula was used to express the colour differences.

Testing

The washing, rubbing, perpiration, water and light fastness tests of printed samples were determined according to ISO 105:C06 (A1S), ISO 105-X12, ISO 105:E04, ISO 105:E01 and ISO 105-B07:2010 standards, respectively.

The ISO 105: C06 A1S fastness test was carried out at 40 °C or 30 min containing 10 steel balls. The printed patterns were exposed to the light for 48 h. Pattern/Print Durability Test Method was used to assess the durability to washing of applied patterns and print.

RESULTS

The colorimetric parameters and colour differences for the printed organic cotton fabrics are given in Table 1.

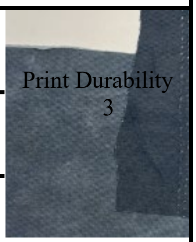
Table 1. CIELab values and colour differences of the printed organic cotton fabric

Samples	Colour Coordinates			Colour Differences (DE $_{CMC\ 2:1}$)
	L*	a*	b*	
Pantone 19-3918 TPG**	44.52	0.13	-10.06	2.03
Indigoteria	46.93	1.31	-10.87	
Pantone 12-0712 TPX**	61.21	10.31	17.11	2.61
Terminalia Chebula-a	58.65	7.99	14.22	
Pantone 17-1225 TPG**	65.68	3.57	18.40	5.97
Onion Skin	73.56	6.95	25.22	
Pantone 16-0220 TPX	62.67	-11.78	17.64	2.62
Morus alba L.	65.10	-8.49	15.93	
Pantone 16-0924 TPG	64.97	6.96	23.81	0.57
Terminalia Chebula-b	63.65	7.10	24.14	
Pantone 13-0720 TPG	84.63	-0.19	19.71	2.29
Tagetes erecta	86.12	-1.41	16.79	

**Pantone was taken as 'standard'

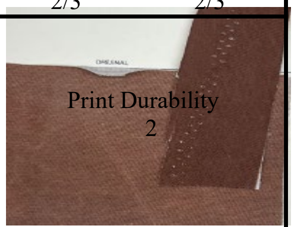
Washing, rubbing, perspiration and water fastness test results were summurized in Table 2-7. In addition to colour properties results, the adequate washing fastness test results were obtained. The dry/wet rubbing, acidic/alkaline perspiration and water test results were found to be quite good grey scale ratings.

Table 2. Fastness test results of printed pattern samples with indigoteria

		*Indigoteria* Staining						Colour Change	Rubbing Fastness	
		WO	PAC	PES	PA	CO	CA		Dry	Wet
Fastness	Washing	4	4/5	4/5	4/5	4/5	4/5	4	2	2
	Perspiration (Acidic)	4/5	4/5	4/5	4/5	4/5	4/5	4	 Print Durability 3	
	Perspiration (Alkaline)	4/5	4/5	4/5	4/5	4/5	4/5	4		
	Water	4/5	4/5	4/5	4/5	4/5	4/5	4		

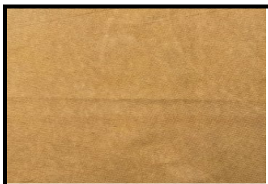
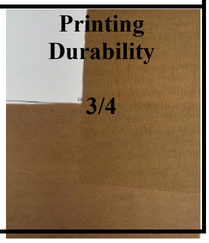
As shown in Table 2, washing, perspiration and water fastness test results of printed patterns with Indigoteria were to be quite good (4+). The dry/wet rubbing fastness results were to be quite low (2) and needed to be improved. The print durability of the samples were moderately.

Table 3. Fastness test results of printed pattern samples with *Termina chebula* ‘a’

		*Termina Chebula ‘a’* Staining						Colour Change	Rubbing Fastness	
		WO	PAC	PES	PA	CO	CA		Dry	Wet
Fastness	Washing	4/5	4/5	4/5	4/5	4	4/5	2/3	2/3	2/3
	Perspiration (Acidic)	4	4/5	4/5	4/5	4	4	4	 Print Durability 2	
	Perspiration (Alkaline)	4/5	4/5	4/5	4/5	4/5	4/5	2/3		
	Water	3/4	4	4	4	3/4	4	3/4		

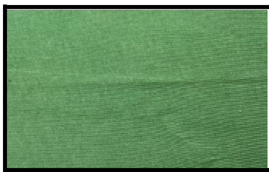
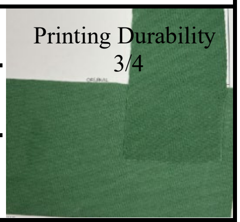
In Table 3, colour changes were seen slightly more. The dry/wet rubbing fastness results were to be quite low (2/3) and needed to be improved. The print durability of the samples were also low. Other fastness results were to be acceptable.

Table 4. Fastness test results of printed pattern samples with *Onion skin*

		***Onion Skin*** **Staining**						**Colour Change**	**Rubbing Fastness**	
		WO	**PAC**	**PES**	**PA**	**CO**	**CA**		**Dry**	**Wet**
Fastness	**Washing**	4/5	4/5	4/5	4/5	3	4/5	3/4	3	4
	Perspiration (Acidic)	4	4/5	4/5	4	2/3	4/5	4	 **Printing Durability 3/4**	
	Perspiration (Alkaline)	4	4	4	3	3	3	4		
	Water	4	4/5	4/5	4	2/3	4	4		

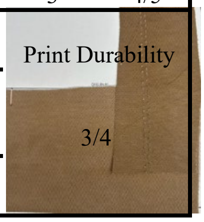
The fastness properties and printing durability of printed patterns with Onion Skin, as summerized in Table 4, were acceptable and high (3 +).

Table 5. Fastness test results of printed pattern samples with *Morus alba*

		*Morus Alba L.* Staninning						Colour Change	Rubbing Fastness	
		WO	PAC	PES	PA	CO	CA		Dry	Wet
Fastness	Washing	4/5	4/5	4/5	4/5	4/5	4/5	3/4	2/3	4/5
	Perspiration (Acidic)	4/5	4/5	4/5	4/5	4/5	4/5	4/5	 Printing Durability 3/4	
	Perspiration (Alkaline)	4/5	4/5	4/5	4	4/5	4/5	4/5		
	Water	4	4	4	4	4	4/5	4/5		

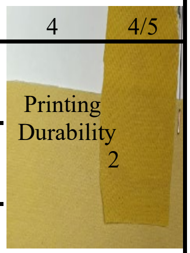
In Table 5, the fastness properties and printing durability of printed patterns with Morus Alba, were acceptable and quite high (3/4 +).

Table 6. Fastness test results of printed pattern samples with Terminalia Chebula-b

		*Terminalia Chebula-b* Staining						Colour Change	Rubbing Fastness	
		WO	PAC	PES	PA	CO	CA		Dry	Wet
Fastness	Washing	4/5	4/5	4/5	4/5	4/5	4/5	3/4	3	4/5
	Perspiration (Acidic)	3/4	4	4	4	4	4	3/4	 Print Durability 3/4	
	Perspiration (Alkaline)	3/4	4	4	4	4	4	4		
	Water	4	4	4	4	4	4	4		

As shown in Table 6, the fastness properties and printing durability of printed patterns with *Terminalia chebula*-b, were generally quite high (3/4 +).

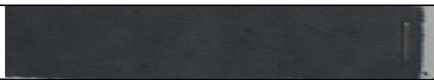
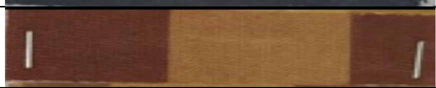
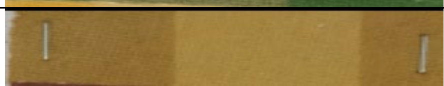
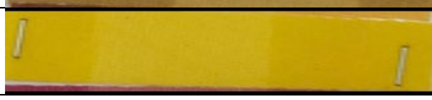
Table 7. Fastness test results of printed pattern samples with Tagetes erecta

		Tagetes Erecta Staining						Colour Change	Rubbing Fastness	
		WO	PAC	PES	PA	CO	CA		Dry	Wet
Fastness	Washing	4/5	4/5	4/5	4/5	2/3	4/5	3	4	4/5
	Perspiration (Acidic)	3/4	4/5	4/5	4	3	4	4/5	 Printing Durability 2	
	Perpiration (Alkaline)	3	3/4	3/4	2/3	3	3	1/2		
	Water	3	4	4	4	2	4	4		

When examined the results in Table 7, it has been observed that Tagetes Erecta is sensitive to alkaline. Except for alkaline perspiration fastness, other fastness results were good. It is thought that the reason for the low printing durability is this alkaline sensitivity.

Light fastness test results of all printed patterns were to be look into Table 8.

Table 8. Light fastness test result

Natural Dye	Light Fastness Test Results	
	Test Sample	Blue Scale Rating
Indigoteria		4
Terminalia Chebula-a		1
Onion Skin		1
Morus Alba		1/2
Terminalia Chebula-b		2
Tageres Erecta		3

The light fastness test results obtained were found to be low as in natural dyeing. Light fastness in printing needs to be improved.

All the patterns on the fabric are printed acceptable dark colours. They have clear contours. Generally all colours except onion, found close to Pantone. However, this situation was not considered as a problem throughout the printed fabric. Studies on printing with this natural dye (onion skin) will continue.

CONCLUSION

When all the results are evaluated in general, it is seen that different natural dyes can be used together to colour fabrics by printing technique under industrial conditions.Target colours can be easily achieved with a small amount of dyestuff compensation to the printing paste. All prints are repeatable. The fact that different natural dyes have different fastness properties seems to be disadvantage for the whole fabric. However, the development and application of inovative finishing processes after the printing will improve the fastness properties and printing durability.

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CHARACTERISTIC PROPERTIES AND ENVIRONMENTAL EFFECTS OF THE NATURAL POLYMER CHITOSAN

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ABSTRACT

This paper provides a review of the characteristic properties and environmental effects of the natural polymer chitosan. Chitosan is a polymer derived from a natural source found in the shells of marine crustaceans and is considered an important alternative in terms of environmental sustainability and biocompatibility in various industrial applications.

The basic properties of chitosan such as its source, biocompatibility, antimicrobial properties, water absorption capacity and chemical modification ability are discussed in detail. At the same time, chitosan's environmental impacts, biodegradability, renewable resource and chemical waste reduction potential were also evaluated.

The history of chitin and chitosan is also highlighted in terms of the scientific discovery of these natural polymers and the development of their industrial use.Chitin was identified in the late 19th century, and the isolation of chitosan to obtain a more flexible material occurred in the mid-20th century.These processes enabled a better understanding of the properties and applications of chitin and chitosan.

The usage areas of chitin and chitosan are also discussed in the paper.These areas include the food industry, pharmaceutical industry, biotechnology, antimicrobial substances, medical applications, textiles, paper, agriculture and environmental protection. Each demonstrates that chitosan is a versatile and environmentally friendly material.

As a result, chitosan has the potential to find more applications as a sustainable material, reducing environmental impacts and contributing to a green future.Therefore, further research and use of chitosan is important to promote environmental

sustainability.Chitin and chitosan, obtained from natural sources, stand out as a remarkable material in a period when environmental and ecological awareness is increasing, with its biological compatibility and environmental benefits.
Keywords: Chitin, Chitosan, Biopolymer, Environmental Effects

INTRODUCTION

History of Chitin and Chitosan

Chitin and chitosan are the second most common polymers found in nature. It is found in both plant and animal cells, but is most commonly found in the shells of crustaceans and the shells of insects.

The first description of chitin and chitosan dates back to 1811. French botanist and chemist Henri Braconnot tried to dissolve the chitin found in mushrooms with sulfuric acid, but was unsuccessful.

In 1894, German chemist Hoppe-Seyler processed chitin (deacetylation) using potassium hydroxide at 180°C. As a result of this process, chitosan with reduced acetyl content was obtained.

The first comprehensive publication on chitin and chitosan was made by Italian scientist Muzarelli in 1977. Muzarelli has published a comprehensive review on the chemical structure, physical properties, and biomedical applications of chitin and chitosan.

Since 1977, research on chitin and chitosan has gradually increased. These studies have shown that chitin and chitosan can be used in various industrial and medical applications.

Outlines of the Historical Development of Chitin and Chitosan

1811: Henri Braconnot describes the chitin.

1894: Hoppe-Seyler obtains chitosan.

1977: Muzarelli publishes a comprehensive review of chitin and chitosan.

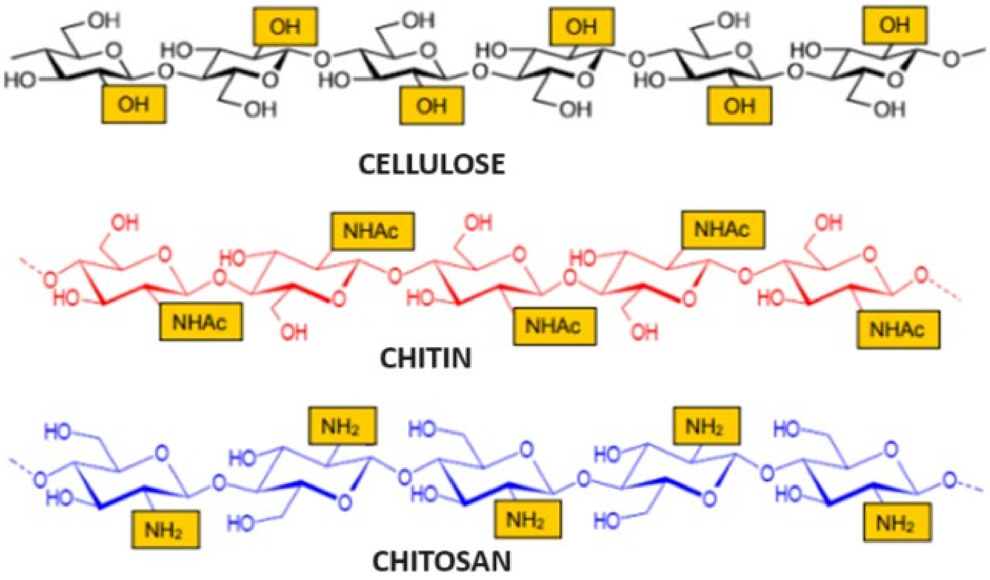

Figure 1. Cellulose, Chitin and Chitosan

Chitin is the most common biopolymer after cellulose and is found in the cell walls of shellfish, insects, and fungi.

Chitin is a biopolymer, that is, a compound consisting of monomers linked in long, repeating units. Chitin monomers are N-acetyl-glucuronic acid and N-acetyl-manuronic acid. These monomers are linked together by β-1,4 glycosidic bonds.

Chitosan is an aminopolysaccharide obtained as a result of the deacetylation process of the chitin molecule. During the deacetylation process, the N-acetyl groups of the chitin molecule are replaced by hydroxyl groups.

Etymology of Chitin

The word chitin was first defined by French chemist Henri Braconnot in 1836. Braconnot isolated chitin from fungi and named it "chitine". The English word "chitin" is derived from here.

The origin of the word chitin is based on the Latin word "chitōn". The Latin word "chitōn" was used to name chitin, a material that forms the shells of molluscs. The word is related to or influenced by the Central Semitic word "kittan", the Greek word "khitōn", the Akkadian word "kitû" or "kita'um", and the Sumerian word "gada" or "gida".

General Information

Chitin is a biopolymer widely found in nature. It is the second most common natural polymer in the world after cellulose.

The key resources for the chitin are:

Shellfish: Lobster, crab, shrimp, mussels, oysters, etc. Seashells are the most important source of chitin. These shells consist of approximately 75-95% chitin.

Insects: Ants, butterflies, beetles, etc. The exoskeletons of arthropods consist of approximately 30-50% chitin.

Fungi: Fungal cell walls consist of approximately 20-30% chitin.

Cephalopods: Cuttlefish, octopus, etc. The mouthparts of cephalopods consist of approximately 10-20% chitin.

Molluscs: The toothed tongues (radulas) of molluscs consist of approximately 10-20% chitin.

Chitin serves various functions in these creatures. It functions as protection and support in the exoskeletons of crustaceans and arthropods. It functions as structural support and water retention in fungal cell walls. It functions in the mouthparts of cephalopods to catch and hold. It functions to grind and break down food in the toothed tongues of molluscs.

Chitin is a biodegradable and environmentally friendly material. Therefore, it is used in various industrial and medical applications.

Figure 2. Chitin and Chitosan

Chitosan is the most important product of chitin and can be obtained by deacetylation of chitin in a basic environment. Chitosan can be found in different shapes such as irregular structure, primary, crystal or semi-crystal.

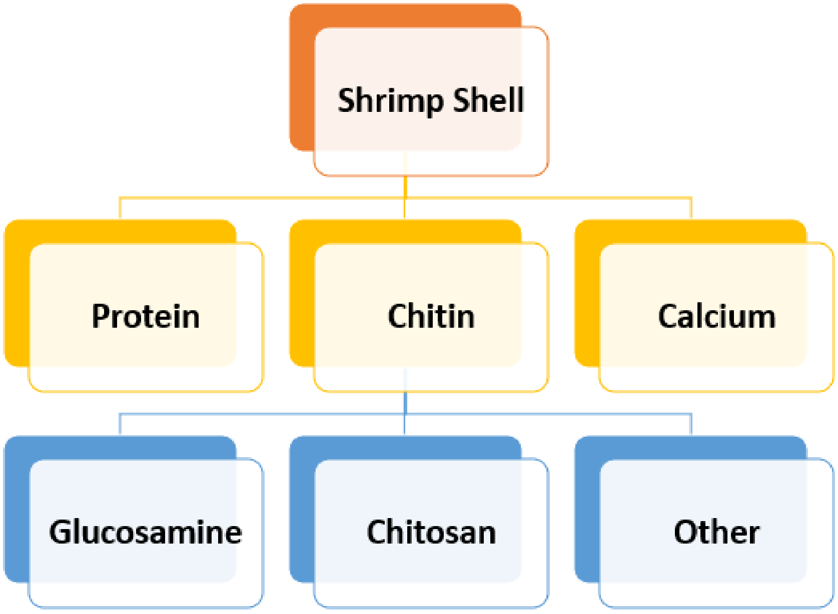

Figure 3. Formation of Chitosan from Shrimp Shell

MATERIAL AND METHOD

Characteristic Properties of Chitosan

Chitosan is obtained by deacetylation of chitin, and the deacetylation process is the process of replacing the N-acetyl groups of the chitin molecule with hydroxyl groups.

Chitosan is a material that exhibits various properties. These properties make chitosan ideal for a variety of applications. The properties and applications of Chitosan are:

Biocompatibility: Chitosan is a biocompatible polymer. This means it is degradable in the human body and non-toxic. Therefore, it can be used in medical applications. Chitosan can be used as wound dressings, drug carriers, and to support the regeneration of tissues.

Antimicrobial Properties: Chitosan may have antimicrobial activity. This can inhibit the growth of bacteria and fungi. Therefore, it can be used as an antimicrobial agent in areas such as food preservation, medical applications and water purification.

Gel Forming Ability: Chitosan has the ability to form gels when in contact with water. This property can be used as a thickener and stabilizer in drug delivery systems and the food industry.

Polymeric Structure: The polymeric structure of chitosan allows its molecular weight and degree of deacetylation to be adjusted. This allows it to be used in different applications.

Biological Activity: Chitosan can stimulate biological activity at the cellular level and influence immune system responses. This property is important in some medical applications and in the field of tissue engineering.

Water Permeability: Chitosan can control the evaporation of water thanks to its water permeability feature. This feature can be used for moisture control in the textile industry and food packaging.

Biodegradability: Chitosan is an environmentally friendly polymer and is biodegradable. Therefore, it can be preferred in the production of more environmentally sustainable materials.

RESULTS

Environmental Effects of Chitosan

The environmental impacts of chitosan are due to its natural origin and biodegradable property. Chitosan can be used in the following environmental applications:

Biodegradability: Chitosan is naturally degradable and non-toxic to the environment. Therefore, it can be used to evaluate waste products and reduce environmental pollution.

Water purification and cleaning: Chitosan can be used to remove bacteria and fungi in water thanks to its antimicrobial properties. It can also be used to remove contaminants from water.

Agricultural applications: Chitosan can be used to support the growth and development of plants. It can also be used to remove contaminants from soil.

Food preservative: Chitosan can be used to prevent food spoilage. It can also help preserve the nutritional value of foods.

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THE PAST, PRESENT AND FUTURE OF ROOT DYEING

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ABSTRACT

Madder (*Rubia tinctorum*), a valuable member of the *Rubiceae* family and widely used since ancient times, contains valuable dyestuffs such as alizarin and purpurin. Currently, this valuable plant is not only used as a dyestuff, but also in the production of medicinal drugs and in the development of some industrial products. Today, research has proven its anti-inflammatory, anti-tumor, antimicrobial, antiviral, antimicrobial, antiviral, analgesic and antioxidant, anticancer, birth facilitator, anti-malarial, anti-inflammatory effects. In the second half of the 19th century, after some synthetic dyestuffs were produced, natural dyeing and therefore natural dyestuffs came to the point of disappearance. Although Anatolian weaving and natural dyeing have been gradually declining and forgotten since the second half of the 20th century, they are still kept alive traditionally in some of our provinces and projects continue to be carried out in areas such as agriculture, textiles and cosmetics. This review provides an overview of the history, advantages, disadvantages, projects carried out in the world and in Turkey, and finally the economic importance of stem dyeing in the world and in Turkey.

Keywords: Madder, Rubiceae, alizarin, price of madder, trade of madder

INTRODUCTION

History of Madder

Many species of the *Rubiaceae* family are an important source of natural dyes used in textile coloring. The roots and rhizomes of these plants contain red colored natural pigments. These pigments have been used for dyeing wool and cotton since ancient times.

The use of the species of the plant *Rubia* sp, a valuable member of the *Rubiaceae* family, dates back to ancient times. During archaeological excavations in Mohenjo

Daro in the Indus Valley of Pakistan, fragments of two money bags dating back to 3250-2770 BC were found. It is assumed that the purple-colored cotton fabric on these pieces was dyed with madder. The Romans were the first to bring this plant to Central Europe and cultivate it. The Arabs brought this plant to Europe after the Romans. In the 4th century, after the fall of the Roman Empire, the trade and cultivation of madder came to a standstill. In the 8th century, the cultivation of madder started in Europe, even in small quantities. Later, Baghdad became an important dye trade center by the 10th century, the Netherlands and Germany were well advanced in the world's production of madder. Dutch and German merchants exported large quantities of local and imported madder to England and Norway. Until the early 18th century, India was the best at dyeing red cotton, importing the dye from the Middle East. However, when alizarin, the dyestuff of madder, was synthetically obtained and put on the market in 1868 its cultivation gradually decreased (Dolen, 1992).

Natural dyeing using plants in Anatolia dates back to ancient times. During the Ottoman period, dyeing was practiced and dye plants were grown in places where handicrafts such as carpet and rug making were practiced. Bursa, Istanbul, Tokat, Kayseri, Ankara and Konya were the leading centers. The culture of the madder, an important dye plant in dyeing, has been practiced since the Middle Ages. In the 1700s, two-thirds of the world's need for madder was met by production in Anatolia. The value of madder sold to foreign countries from the port of Izmir until 1875 reached 5.000.000 gold coins. Madder was known as Turkish Red, Edirne Red and Alizarin in the history of dyeing (Genc, 2014).

Synthetic Dyes and Natural Dyes

Natural and ecological products are a subject of interest in many fields today. With the increase in conscious consumers around the world, the theme of "Ecological Product" appears in many different disciplines. Under this theme, the use of natural and sustainable raw materials has become more popular. In this context, the use of natural dyes has gained importance in the textile industry. The negative effects of synthetic dyes on health and the environment cause natural dyes to be preferred. The main ingredient used to synthesize synthetic dyes is coal tar, which causes nausea, allergies, skin disorders and many health problems (Sani et al., 2016). Due to the harmful effects of synthetic dyestuffs, research on products obtained by using natural colors and pigments in many sectors is increasing day by day (Leon et al., 2015).

Advantages and Disadvantages of Madder

i. Madder creates pastel and bright shades of color that are flashy, vibrant and have a calming effect on people (Khattak et al., 2019).

ii. This plant, which reveals the magic of colors, can create many different shades of color by combining traditional knowledge, craftsmanship and the power of mordants.(Khattak et al., 2019).

iii. It is known that salmon (dyeing with copper), coral (without mordant), bright red (dyeing with alum), brown red (dyeing with ferrous sulfate), dark red tones and purple (iron, citric acid, tartar) colors are obtained with different mordants (Karadag, 2007; Dean, 2003). In addition to these colors, it was stated that various colors such as linden blossom, dark hornbeam, dark rose dry, light rose dry, dark cherry rot, calf's tongue, light yellowish red, coffee with milk, wine color, rotten medlar, alder, cinnamon, light burgundy, light red brown, deer brown and dark red were obtained (Esberk, 1947).

iv. Madder contain natural dyestuffs with antitoxic, antitumorogenic, antiallergic structure (Khattak et al., 2019). The roots of these plants contain natural pigments such as alizarin, pseudopurpurin, purpurin, munjistin, rubiadin, xanthopurpurpurin, purpuroxanthin, lucidin, chinizarin, christofin and anthragallol. Synthetic dyes are chemically synthesized from coal tar. Synthetic dyes can cause allergies, toxic waste and harm to the human body (Samanta and Agarwal, 2009).

v. Hair dyes produced using madder do not show toxicity, but hair dyes containing mineral or metallic components carry potential toxins such as lead and silver salts and pose a danger to human health (Vankar, 2016).

vi. Natural dyestuffs obtained from plants grown with the abundance of agriculture can be transformed into a natural fertilizer form by re-mixing into nature in a soluble form where they belong.

vii. Due to the presence of alkaloids, phenols, cardiac glycosides, flavonoids, terpenes, tannins, coumarins and essential oils in its structure (Nasrollahzadeh et al., 2019), it has antibacterial, antifungal, antiviral, antiparasitic and insecticidal properties. Due to these properties, it is used in many industries such as medicine, health, cosmetics, agriculture and food (Hoseinzadeh, 2020).

viii. It can be easily used in painting wooden toys, it has no harm in terms of health, but it is much longer lasting than synthetic paint because its fastness values are quite high (Okca, 2017).

ix. The cultivation of madder is seen as a less costly and profitable business compared to other plants.

x. Obtaining and using madder provides many environmental and social benefits. Its processing in different application areas from planting to obtaining the final product provides employment opportunities for the people involved in these activities and does not carry any risk for the employees. However, various studies have shown that synthetic dyes have mutation accelerating (Mathur and Bhatnagar, 2007; Przybojewska et al., 1989), genotoxic (Sharma and Sobti, 2000), carcinogenic, dysfunctional, sperm motility inhibiting effects on workers working in synthetic dye manufacturing companies (Dogan et al., 2005; Birhanli and Ozmen, 2005; Hoke and Ankley, 2005).

xi. In recent years, it has been proven that natural dyes will contribute to the prevention of the climate crisis by reducing fossil fuel dependency (Aslan, 2023).

For these reasons, obtaining and using natural dyes, especially the madder plant, which is characterized as 'Edirne Red', should be considered as a sustainable option. In addition to these, madder has some disadvantages.

i. It is very difficult to develop a formula for the use of natural dyes, because the formation of color can vary depending on morphogenetic, ontogenetic, diurnal, ecological factors variability and finally dyeing conditions.
ii. The price of natural dyes is very high and requires 10 times more than synthetic dyes to reach the end consumer
iii. Scientific techniques for natural dyeing have not been studied in detail and many aspects of natural dye plants remain incomplete.
iv. The lack of clear technical information on extraction and dyeing techniques makes it difficult to determine appropriate procedures for each plant.
v. More studies are needed on the performance of natural dyes on textiles. After the color is fixed, the color exposed to different chemicals may change undesirably (Affat, 2021).

Projects Organized Around the World

The use of dyestuffs in Europe is regulated by the European Laws 2002/61/CE. The European laws are in line with the agricultural policy (Luxembourg Treaty, June 23, 2003), which increased interest and political initiatives for natural products. This shows a renewal in the use of natural dyes, with the directive also addressing the toxicity problems caused by synthetic dyes. Different projects for the cultivation of dye crops are underway in Europe. These include the PRISCA project in Italy (production and dye production from *Reseda luteola*, *Rubia tinctorum* and *Isatis indigotica*), the INDINK project in the UK (focused on more efficient production of indigo from Isatis tinctoria) and the SPINDIGO project in Europe (production and dye production from Isatis tinctoria, Polygonum tinctorium) (Guinot et al., 2006).

The most prominent attempt to revitalize madder in Turkey is the DOBAG (Natural Dye Research and Development) project initiated by Marmara University Faculty of Fine Arts in 1982. Within the scope of this project, old carpets and rugs dyed with natural dyes and woven on looms were examined, and techniques such as TLC, HPLC and HPLC/MS were used to determine which dye plants, dyestuffs and mordants the colors were obtained from (Baydar and Biyikli, 2019). Currently, natural dye certificates are given to domestic and foreign natural dye producers with analyzes supported by academic studies.

The second of the initiatives for the revitalization of madder in Turkey is Trakya University. Trakya University has initiated studies in scientific, cultural, artistic and many fields in order to bring Edirne Red to the city identity and in this direction, it has created the "Edirne Red Strategic Plan" strategic plan and as a part of this, it has taken action for academic studies. After the "1st International Edirne Red e-Symposium" held on October 20, 2020, the madder was planted and harvested after the 2nd International Edirne Red e-Symposium was held on October 2, 2023.

Economic Importance of Madder

As a result of recent surveys, madder has started to regain its commercial value, although not as much as before. Nowadays, the prices of madder have increased considerably (Table 1 and Table 2). The tables provided by the user show the domestic and international prices of different products obtained from the madder plant.

The commercial value of madder powder in Anatolia from past to present is shown in Table 1. In the Ottoman period, the price of madder powder was 24-26 Ottoman coin (1283 grams) and today it is valued at 14-17 US dollars per kg. The table also shows that the origin of the madder powder affects its price.

The economic importance of madder in the world is shown in Table 2. It can be seen that the price of madder products varies according to the supplier, quality and concentration of the extract. The table shows that the main supplier of madder products is China, offering a price range of US$10 to US$70 per kg depending on the raw material. The table also shows that Iran is another supplier of madder products and offers raw rhizomes at affordable prices.

Table 1. Commercial value of madder in Anatolia from past to present

Supplier	Madder Materials	Species	Origin	Amount	Cost	Price
Ottoman	Powder	*R. tinctorum*	Domestic (1) Foreign (2)	1 oke:1283 gr	24 coin (1) 26 coin (2)	28 coin (1) 30 coin (2)
Konya	powder	*R. tinctorum*	Turkey	1 Kg	-	$14
Antalya	powder	*R. tinctorum*	Turkey	1 Kg	-	$17
Aksaray	powder	*R. tinctorum*	Persia	1 Kg	-	$15
Mugla	extract	*R.cardifolia*	İndia	100 g	-	$30

Table 2. Economic importance of madder in the world

Madder Materials	Quantity	Supplier-1 (China)	Supplier-2 (China)	Supplier-3 (China)	Supplier-4 (Persia)
raw rhizome	1 kg	-	-	-	$3
Powder	1 kg	$10	$18	-	-
extract (5:1)	1 kg	$15	$18	-	-
extract (10:1)	1 kg	$22	$19	$20	-
extract (20:1)	1 kg	$35	$20	$30	-
extract (A quality)	1kg	$70	-	-	-

Dyeing houses and textile companies that dye with madder import it from Iran. Consumers complain that imported this product powders are adulterated and very expensive. In Turkey, there is no set base price and it is usually sold at exorbitant prices through Aksaray. Recently, due to decrease in imports, many dye plants in Turkey have been over-collected from their natural habitats, and those that were not collected have been destroyed by spraying in agricultural fields. For this reason, madder is subjected to genetic erosion and its natural populations are gradually being damaged. Although Turkey's need for madder cannot be met by collecting from nature, genetic resources will face the threat of being lost. Considering that the rhizome yield of rhizomes is 30% of that of fresh rhizomes, 36.6 tons of fresh rhizomes are collected for 11 tons of rhizome need, it is concluded that this need can only be met by cultivating the plant, which this knowledge was obtained from a limited number of places during the survey visit.

CONCLUSION

The madder plant has a bright future as a natural dye source for various industries. However, it is not enough to cultivate the plant, but also to research the cultivation methods, the raw material extraction, and the application of the plant to industrial field, as it is done in many European countries. Nowadays, many countries use organic dyes to color toys, clothes, and other items for babies. The demand for natural dyes is increasing day by day, but to meet this demand, breeding studies should be done on plants such as madder, woad, weld. Also, projects related to these plants should be funded, and new workshops and artists should be trained to revive the art of madder dyeing.In addition to these steps, the following actions should be taken to enhance the economic value and sustainability of the madder plant: Laws and regulations should be enacted to protect the madder plant from overexploitation, genetic erosion, and environmental degradation. The madder plant should be recognized as a valuable natural resource and a cultural heritage.Projects and funds should be allocated to support the export and import of madder products, especially to the European market, where the demand for natural dyes is high. The quality and safety standards of the madder products should be ensured and certified.The sales of natural dyes and the products dyed with them should be promoted and marketed, especially the traditional carpets that are hand-woven and dyed with madder. Natural dyed carpets should be highlighted as unique and authentic artworks that reflect the history and culture of the country.

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INTRODUCTION OF MADDER PLANT (*RUBIA TINCTORUM* L.) AND ITS DISTRIBUTION AND HABITATS IN IRAN

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ABSTRACT

The tradition of herbal dyeing in Iran has a long history. This country is considered one of the richest and most important regions in the world in terms of natural dye plants. Natural dyes have been produced and continue to be produced in Iran for centuries for use in the carpet, fabric, felt and tile industries. The dye plants that grow in natural environments are very diverse. In vegetable dyeing, the whole plant and sometimes a part of aerial or underground organs such as leaves, roots, branches, trunk skin, onion tuber skin, etc. are used. The madder plant (*Rubia tinctorum* L.), which has a special place in vegetable dyeing, is one of the most important of these plants. The underground shoots of this plant are used. This perennial plant is widely used as a dye in the cosmetic, textile, food and pharmaceutical industries. It is possible to find the habitats of this plant in different geographical regions of Iran. The aim of this study is to reveal the distribution and habitats of madder in Iran and also its importance in vegetable dyeing.

Keywords: Madder (*Rubia tinctorum* L.), Vegetable Dyeing, Habitat, Distribution.

INTRODUCTION

This perennial plant with the scientific name of *Rubia tinctorum* L. belongs to the Rubiaceae family and is one of the important industrial (dyeing) and medicinal (anti-cancer and anti-gout) plants. Its main habitat is the Mediterranean region (Namjouyan et al., 2010). Its green leaves are oval, long, sharp and its small yellow flowers (5 to 10 mm) are compactly located on the inflorescence. Its economic value is in the root part (rhizome). The diameter of the roots is 1.5 to 2 cm and its length sometimes reaches more than 100 cm (Zargari, 1982). It is reported that this plant tolerates soil salinity of up to 18,000 μm well and produces an acceptable yield (Mirabzadeh Ardakani, 1998). In a field experiment that was conducted under the title of effect of nitrogen and phosphorous fertilizers on the yield and secondary metabolites (such as proline and phenol) of medicinal plant *Rubia tinctorum* L. under saline conditions, it was found that yield and secondary metabolites increased with an increase in nitrogen and phosphorous treatment in the salt stressed madder (Zamani et al., 2014). Reviews show that salinity is one of the most important abiotic stresses that affect agricultural plants and decrease strongly their yields. At the moment about %50 of the fields in Iran is faced with the salinity problem (Anonymous, 1997). Modification of saline soils with agricultural purposes is too costly and difficult. Using resistant cultivars such as barley and *Rubia tinctorum* L. (madder) can help making the best use of saline soils (Mirabzadeh Ardakani., 1998; Dadashi et al., 2007). This plant is used in the treatment of kidney and bladder diseases and is antiseptic and relaxing (Zamani, 1991). The roots of Rubia tinctorum L. (madder) are the source of a natural dye that have been used to dye textiles in many parts of the world since ancient timesand. The dye components are anthraquinones which probably contribute to the resistance of the plant against fungi in the soil. Alizarin is supposed to be the main dye component of this plant (Goverdina et al., 2002). As the age of the roots increases, the percentage of colored substances (Alizarin) also increases in the roots of this plant (Derksen and Van Beek, 2007; De Santis and Moresi, 2007). The *Rubia* genus includes major groups of medicinal plants such as *Rubia cordifolia*, *Rubia tinctorum*, and *Rubia akane*. They contain anthraquinones (AQs), particularly alizarin and purpurin, which have pharmacological effects that are anti-inflammatory, antioxidant, anticancer, hemostatic, antibacterial, and more. Alizarin and purpurin have been utilized as natural dyes for cotton, silk, and wool fabrics since the dawn of time. Due to the presence of secondary metabolites in them, several *Rubia* species are well known for their economic and commercial significance. Major secondary metabolites recovered from *Rubia* species include anthraquinones (AQs), naphthoquinones, terpenes, and iridoids; anthraquinones and their glycosides are prominent among them. Since ancient times, AQs derived from various *Rubia* species have been utilized as natural colorants. The term “Madder” refers to *Rubia* species that produce colorants from different plant parts, particularly roots. Five main species produce AQs and their derivatives: *Rubia tinctorum* L. (Murthy et al., 2023). Among the anthraquinone dyes, Alizarin and its derivatives are well known colorimetric reagents (Sharda Sanjay et al., 2010).

Table 1. Scientific classification

Kingdom	Plante
Clade	Tracheophytes
Clade	Angiosperms
Clade	Eudicots
Clade	Asterids
Order	Gentianales
Family	Rubiaceae
Subfamily	Rubioideae
Type species	*Rubia tinctorum* L.

Figure 1. *Rubia tinctorum* L.

Figure 2. Madder roots (*R. tinctorum* L.) products

DISTRIBUTION, HABITATS AND HISTORY

For roughly four thousand years the pulverized roots of (*Rubia tinctorum* L.) madder have been used in Asia, North Africa and Europe as a red dye. Madder's original, natural habitat extended from Iran to the Mediterranean and madder roots were gathered, processed and used long before the plant was systematically cultivated. Although the red dye derived from madder was put to various uses, the dyeing of fibres for use in textiles and carpets was the primary one, and is first attested c. 2000 BC in Mesopotamian cuneiform sources. In Iran madder's use can be traced from late Antiquity to the modern era (Potts, 2021). According to historical documents, this plant was cultivated in Iran in the 6th century BC, the Sassanid period (Bagheri Zonoz., 2003; Fazel Pour, 2001; Birjandi, 2008). There are also reports that this plant was cultivated in the 10th century in Iran's Khorasan province (Olfati, 1995). In the root of some species, it is a biological feature that causing phagocytosis, it can be mentioned. In addition, the antimicrobial effect against some microbes scattered in the air such as *Aspergillus niger* and all kinds of harmful soil fungi this plant has been attributed (Namjouyan et al., 2010)

Rubia grows wild in the western regions of Iran, around Mount Damavand, Yazd, Ardakan, Urmia, Khoi, Dilman and Tabriz. The cultivation of this plant is mostly in Yazd and Kerman provinces. Ardakan city in Iran is one of the hubs of Rubia production due to its saline soils and other climatic conditions suitable for growing this plant, and the average dry root yield is more than 9 tons per hectare (Koocheki et al., 2018). The genus Rubia in Iran has 8 species. Rubia perennial plant is a climbing herb with black fruits, which is a plant from the Irano- Turanian Region.It is distributed in the northwest and center of Iran (Potts, 2021).

MATERIAL AND METHODS

The research method was based on the search of articles published in different years in Iran and the world. Regarding the Rubia species, its habitat, properties and uses. The search was done on Google Scholar, Sciencedirect, PubMed and other reputable scientific sites with suitable keywords and then the contents were summarized.

Description

Rubia tinctorum L. can grow up to 1.5 m in height. The evergreen leaves are approximately 5-10 cm long and 2-3 cm broad, produced in whorls of 4-7 starlike around the central stem. It climbs with tiny hooks at the leaves and stems. The flowers are small (3–5 mm across), with five pale yellow petals, in dense racemes, and appear from June to August, followed by small (4–6 mm diameter) red to black berries. The roots can be over a metre long, up to 12 mm thick and the source of red dyes known as rose madder and Turkey Red. It prefers loamy soils (sand and clay soil) with a constant level of moisture (Assadi and Mozzaffarian, 2014).

RESULTS

Unfortunately, in recent years, a significant percentage of Iran's agricultural land has moved towards salinization due to various reasons, including the decrease in rainfall, the global warming phenomenon, excessive use of chemical fertilizers, etc., especially in arid and semi-arid areas. One of the basic and natural features of salty and dry plants their durability and survival is good in salty soils and dry conditions. Rubia is also one of these plants that produce other crops in dry and salty lands. It was accompanied by a decrease in performance, or their products were uneconomical. it will be able to perform well in addition to reviving the land to have It has been reported that Ronas can tolerate salinity Up to 18000 μm with the product is acceptable (Namjouyan et al., 2010). According to the results of this research and the distribution of this plant in different climatic regions of Iran, as well as the high compatibility of this important industrial and medicinal plant with soil salinity, it can be concluded that this plant is suitable for cultivation in arid and semi-arid areas. This issue requires additional investigations.

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EDİRNE RED MARKETING MIX ELEMENTS AND MARKETING STRATEGY

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ABSTRACT

Edirne red has become one of the Edirne brand products when it came to the agenda again in 2017. Since this year, national and international studies have been carried out on Edirne red. These studies, which started with a workshop held with Trakya University, Edirne Promotion and Tourism Association, Edirne Municipality and Edirne Governorship, Provincial Culture and Tourism Directorate and relevant experts, included Edirne red themed theatre, concerts, Edirne Red products of textile companies, a meeting, Edirne Red madder plant. Many activities such as harvest days, Edirne Red geographical indication process, TV shootings on national channels, book and novel work, logo work, international symposium have been organized. As a result of these studies, awareness of the importance and meaning of red in Edirne increased and product diversity tried to find its place in a concrete sense. These studies carried out so far create both economic and spiritual added value to the city and contribute to the sustainable brand city process.

In the sustainable brand city process, it is vital that the new product or service that is created for the city of Edirne takes its place in the real market and is accepted. The marketing stages of Edirne Red, which has come to the agenda as a new brand in terms of its historical importance and touristic product variety, should be carefully applied. These practices form the basis for the sustainable branding process of Edirne red for the city of Edirne. Because marketing mix elements constitute the most basic and important factors of the marketing field. It consists of Product, Price, Place, Promotion, People, Physical Evidence and Process elements, which are known as the 7Ps of tourism marketing. Many businesses, cities and national and international successful brands are marketing their sustainable and high added value products by using the mixed elements of this marketing. In the Edirne red branding process, a successful and sustainable branding process can be realized by developing marketing mix elements and adapting them to existing and potential products.

In this section, it has been tried to examine the marketing mix elements within the framework of Edirne red being a sustainable brand in the city and how products that will create added value can be developed.

Keywords: Edirne Red, Marketing Mix, Marketing Strategies

PRUNUS SPP. FRUITS AS NATURAL COLOR CONTRIBUTING AGENTS IN FOODS

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ABSTRACT

Fruits and vegetables are among the most important sources of phytochemicals worldwide, which can also provide a desired color of the food. The sensory perception of the food is directly linked to its color i.e. desired and vivid ones. Thus, color additives, both natural and synthetic, are so important to the food industry. They are able to improve the sensory attributes lost during processing, and to expand product variety. However, studies report a link between synthetic colors and some health disorders. That is why serious attention is paid to natural dyes. In this context, *Prunus* fruits present an excellent alternative source of natural compounds that enable the production of a wide range of coloring molecules, such as anthocyanins, carotenoids and chlorophylls. Moreover, in addition to their ability to color, they also contribute by increasing food's bioactive qualities. Carotenoids are the pigments that give the yellow and orange color to the pulp and skin of apricots and other *Prunus* fruits. Along with them, flavonoids, anthocyanins (purple, blue colors), etc. are also found in prunes, for example. Still, whether the fruit can be used as a reliable source of food coloring is an open question worth answering. Therefore, more research is currently needed to better understand the behavior of natural compounds during the extraction processes and further incorporation into food matrices. In this regard, scientists add fruits directly in the food in order to avoid extraction and potential loss of bioactive compounds, i.e. natural dyes. Regulation approvals should always be considered as well and it has to be noted that different legislation applies to different countries. In view of the

sustainable food cycle provision and the seek for more value added ingredients, natural dyes ought to be taken into account with priority.

Keywords: value added ingredients, natural sources, bioactive compounds

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A MINI REVIEW ON MEDICINAL USE AND PHARMACOLOGICAL PROPERTIES OF *RUBIA TINCTORUM* L.

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ABSTRACT

Rubia tinctorum L. (madder) is a perennial plant belonging to the Rubia species of the Rubiaceae family. Anthraquinones, naturally occurring in the madder roots, have been used for dying textile fibers red color since ancient times.

Current studies have shown that *R. tinctorum* has a wide range of pharmacological properties, such as anti-inflammatory, antibacterial, antifungal, antiplatelet, antitumor, antiobesity, antidiabetic and hepatoprotective effects. Thanks to these effects, *R. tinctorum* has been reported to have therapeutic potential in various diseases such as skin infection, cardiovascular diseases, liver pain, diarrhea, rheumatism, kidney stones, neurodegenerative diseases and cancer.

There are also studies reporting that some compounds isolated from the roots of *Rubia tinctorum*, show genotoxic properties. These observations have implied that long-term medicinal use of madder by humans is associated with the risk of formation of malignant tumours. This has raised some concerns about the long-term use of products containing *R. tinctorum* extracts in humans and reveals the need for new studies on this subject.

Keywords: Madder, Therapeutic potential, Medicinal use, Pharmacological properties, Anthraquinone dye

INTRODUCTION

Rubia tinctorum L. (madder) is a perennial plant belonging to family Rubiaceae (Derksen and van Beek, 2002). In this review, some information on Rubia tinctorum available in the literatüre is summarised.

The roots of madder are the source of a natural dye and they have been used to dye textiles since ancient times. Another application of madder extract is its use as food colourant (El-Tanahy et al., 2022; Derksen and van Beek, 2002).

The dye components of *Rubia tinctorum* are the anthraquinones, such as alizarin, purpurin, lucidin, munjistin, pseudopurpurin, rubiadin, xanthopurpurin, anthragallol and their primeverosides, e.g., lucidin-3-0-primeveroside and ruberythric acid (Eltamany et al., 2020; Derksen and van Beek, 2002). Alizarin is the most well known anthraquinone of madder (Derksen and van Beek, 2002). Anthraquinones, have been found to have pharmacological properties as well as being dye components.

Rubia tinctorum contains different active compounds to prevent diseases related to oxidative stress. Phytochemical analysis of *R. tinctorum* indicated that it is rich in chemical compounds such as alkaloids, phenol, flavonoids, anthraquinones, cardiac glycosides, tannins, coumarins, vitamins and minerals (Houari et al., 2022)

In this review, it is aimed to highlight the medicinal uses and pharmacological properties of *Rubia tinctorum*.

RESULTS

Ethnobotanical surveys have reported that madder is an anti-inflammatory, antibacterial and antifungal agent and its use for treatment of various ailments, such as skin infection, cardiovascular diseases, liver pain, diarrhea, rheumatism, kidney stones and neurodegenerative diseases (Khan et al., 2023; Eltamany et al., 2020). Studies have shown that madder is useful in alleviating dropsy, paralysis, jaundice, amenorrhea and visceral obstructions and can be source of potent antioxidants for treatment of diseases such as cancer. Other findings demonstrated the therapeutic potential of *R. tinctorum* as anti-aggregant effect on platelets, antitumor, antiobesity, antidiabetic, hepatoprotective, vasoconstriction and protective effect on the aorta (Ajjoun et al., 2022; Eltamany et al., 2020).

Because of the application of *Rubia tinctorum* extracts in phytopharmaceuticals and as food colourants studies on the safety of these products have been carried out. It has been reported that compounds such as rubiadin, xanthopurpurine, lucidin, lucidin primeveroside and non-anthraquinone mollugin, which are isolated from the roots of *Rubia tinctorum*, show mutagenicity. These observations have implied that the long-term medicinal use of madder by humans is associated with the risk of formation of malignant tumours (Derksen and van Beek, 2002). This has raised some concerns about products containing *Rubia tinctorum* extracts, despite their medicinal benefits.

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EVALUATION OF THE EFFECTIVENESS OF TEXTILE MATERIALS DYED WITH *RUBIA TINCTORUM*

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ABSTRACT

Microorganisms multiply on textile surfaces in the presence of temperature and humidity. In this situation odor occurs and comfort decreases. It may even be possible for diseases to occur. The purpose of this study; fabrics that can be used in sock production and shoe insoles, dyeing with *R. tinctorum*, determining the amount of alizarin, which is considered to be an effective molecule in dyed fabrics, and examining its potential with antimicrobial and irritant testing. The reduction rates of the antimicrobial effect detected in dyed fabric samples are 82.85% in gram-negative bacteria, 89.66% in gram-positive bacteria and 96.25% in yeast, respectively. In the Hen's Egg Chario-Allontioc-Membrane (HET-CAM) irritation potential measurement test, it was determined that textiles and *R. tinctorum*'s dye solution did not show irritating effects such as lysis, bleeding and coagulation.

Medicinal and aromatic plants provide an alternative to synthetic textile materials thanks to their antimicrobial properties. The most important feature expected from antimicrobial substances to be used in textiles is that they do not adversely affect human and environmental health and do not adversely change other properties of the textile product.

For this reason, in recent years, interest in the production of environmentally friendly and natural-based antimicrobial substances and their textile applications has been increasing rapidly. Thus, an effort was made to develop a cheap, environmentally friendly, sustainable, national, new preliminary product.

Keywords: *Rubia tinctorum*, fabric, antimicrobial, HETCAM

PRODUCTION OF BIOMASS FOR NATURAL DYES WITHOUT AGRICULTURAL APPLICATIONS

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ABSTRACT

Plant cells are the biofactories of valuable chemicals that are often used in industrial applications. These pharmaceutically active chemicals are called secondary metabolites and can only be produced by plant cells. Plant cell and tissue cultures are the alternative way of agricultural applications for plant biomass productions and have some advantages over traditional agricultural techniques: (i) bioactive secondary metabolites can be synthesized under controlled conditions independently from geographical, seasonal variations and environmental factors, (ii) biotechnological procedures can be identified for continuous production of uniform quality and yield, (iii) high-yielding cell lines can be selected for better quality, (iv) a rapid production is possible, (v) harmful herbicides and pesticides are not involved in the production process, (vi) process cost can be decreased by growth control and process regulations, (vii) novel compounds which are not normally found in nature can be synthesized from low-cost precursors in culture conditions. Natural dyes, such as anthraquinones, are the secondary metabolites of plants and can also be produced in plant cell and tissue cultures, independently of agricultural applications. In this presentation, anthraquinone productions of in *in vitro-grown Rubia tinctorum* biomass (root, callus and cell cultures) will be discussed.

Keywords: Natural dyes, Biomass, *Rubia tinctorum*, *in vitro* production

ENCAPSULATED *RUBIA TINCTORUM* L.

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ABSTRACT

Rubia tinctorum, commonly known as dyer's root, is a plant species known for its red dye obtained from its roots. This plant has been used in the dyeing and cosmetic industry for centuries.

Rubia tinctorum is used as a natural hair dye, often when combined with henna. It is responsible for red and orange tones. These natural dyes, which have a low risk of reaction, are a good alternative for people who are sensitive to chemical dyes. Since dyer root contains antioxidant and anti-inflammatory properties, it is not used in various skin care. However, more data is needed on its effect on the skin. *Rubia tinctorum* is also used as a natural colorant in cosmetic products. It is especially available in products such as lipstick, blush and eye shadow.

Various pink, purple and red flexibilities are possible depending on the amount of distribution of *Rubia tinctorum* root powder to color soap or cosmetics. Its CAS number is 84650-16-8 and its EC number is 283-497-9. However, it is important that the FDA provide approved cosmetic colorants for use when coloring specialty cosmetic products, and since madder is not approved as a cosmetic colorant, it operates in cosmetic products of plant natural origin rather than its natural coloring ability. Additionally, madder is not safe for baby products, so it is not used on babies.

The madder has been used in textiles as well as cosmetic products since ancient times. For example, it was used as color cosmetics in ancient Egypt. Various organic compounds derived from plants have been identified in ancient cosmetic products by various analytical techniques. Pink or violet-pink materials have been found in Punic cosmetics dating to the second half of the 1st millennium BC. Archaeological contents of madder use have also been found in various Roman ungueenteria and cosmetic tools

examined with various analytical techniques. Generally, a mordant is needed to use madder in pigment form.

Keywords: *Rubia tinctorum*, cosmetics, hair dye, colorant, madder, skin products.

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FASHION, RED AND MADDER

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ABSTRACT

Color is the first element that attracts the attention of consumers within the concept of fashion as it directly covers the surface of the product. Red is a color with a different history. It has been preferred for centuries due to its attractive chromatic value and dominance over all colors.

Since ancient times, people have tried to find dyestuffs that could reproduce the strong hue of blood, fire, flowers and sunsets. For this purpose, natural dyes, which have an important place in the development of dyeing from the Stone Age to the present day, have given color to many cultural assets such as carpets, fabrics, felt and tiles. One of the most prominent and symbolic plants in the history of dyeing is the madder obtained from *Rubia tinctroum*. This plant has a beauty of color that no synthetic dyestuff can achieve due to its chemical properties.

Red color obtained from madder was widely used by the Turks. The earliest evidence of dyed thread in Turkey dates back to the 3rd millennium BC. As a result of the analysis made on the carpet taken from the Pazyryk Kurgan, it was determined that the red threads were dyed with madder.

The use of alum, which is only found in Tashkent, to obtain Turkish red from madder, shows that Turkish red dyeing was developed by the Turks here and spread to India from there. This red color, which came to Anatolia with migrations, was used by the Turks in Anatolia, and then spread to Europe, preserved its value until the beginning of the 20th century.

Fabrics dyed with madder in Edirne were called "Andrinople" Red (Edirne Red). The technique used to obtain Turkish Red and Edirne Red was used specifically for cotton dyeing and was used to obtain bright red. The technique involved boiling the cotton in olive oil and alkali, respectively, and dyeing it with madder. Beginning in the

1740s, this bright red color was used to dye or print cotton textiles in England, the Netherlands, and France.

The habit of wearing red for symbolic purposes continued for centuries in Europe, sharing similar characteristics. Red, especially the bright Edirne Red, has been very important for both those engaged in sacred work and those who love aristocratic society and luxury.

In the 19th century, synthetic dyes replaced natural dyes in terms of effectiveness and cost and are still widely used today. However, synthetic dyes cause environmental pollution and toxic and allergic reactions in living things. However, in recent years, interest in natural dyes has increased due to longing and demand for healthy living, sustainability and handmade products.In contemporary fashion, the use of madder is seen in eco-fashion or slow fashion trends that are environmentally and health-friendly.

Keywords: Madder, Andrinople Red, Turkish Red, Fashion.

THE FIRST EXAMPLE OF TURK RED FROM ANCIENT TURKS TO THE PRESENT DAY: PAZIRIK CARPET

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ABSTRACT

Evidence has survived to this day that many items that were a part of the daily life of the ancient Turks were colored and painted using various methods. This can be seen especially in the valuable carpets, silks, tiles, weapons and many tools used by the Turks. The color, which has managed to preserve its value for centuries, influenced different ethnic cultures in some periods, and made its name known to the world as "Turkish Red", is the most important example of the Turkish culture's talent in dyeing. The first example of this dyeing method, which is a very important part of Turkish culture, has survived to this day. During the research conducted in the kurgans discovered in the Pazyryk region at the foothills of the Altai Mountains and thought to belong to around 40 ancient Turks (Scythian, Hun etc.), many large and small artifact remains were found. As a result of studies carried out under the direction of Soviet archaeologist Sergei Rudenko, it has been determined that colors such as red, dark red, green, yellow, blue and purple were used in the motifs on the fabrics unearthed from the Pazyryk kurgans, which are thought to date back to the 3rd BC. century. The carpet, found in one of these kurgans and measuring 195x205 cm, went down in history as the first carpet dyed with Turkish Red. This example, known as the Pazyryk carpet, is also considered the oldest carpet in the world. As a result of the analysis carried out on this carpet, which was found to be from the ancient Turks, it was determined that the red threads were dyed with madder.

Pazyryk Carpet, which is similar to Turkmen carpets in terms of weaving style, size and shape, is woven from very fine wool. It has been determined that the method, which is now known as the Gördes knot in the weaving industry, is applied 36 times to each square centimeter of this carpet. This process, which requires great mastery, is a very important evidence showing the extent to which the art of weaving has developed in Turkish culture. At the same time, looking at the content of the colors used in the Pazyryk Carpet shows that madder dyeing was also developed in the ancient Turks. Although the background of this carpet is dark red, some of its shadows are light blue and red, colors in shades of yellow are also used in the carpet. The dominant red color in the carpet is the color known as Turkish Red. Each of the motifs embroidered between the channels on the carpet reflects a part of Turkish culture.

Although the carpet in question bears the traces of Turkish culture, the different opinions of some researchers have been the subject of debate until today. Some researchers, who put forward different ideas on the carpet, have brought the debates about the place of touch to the present day by mentioning the traces of Iranian culture in the motifs and symbols on the carpet. However, studies show that the carpet's motifs, weaving style, red type used and stitch style match the techniques of Turkish masters. These features of the carpet and the fact that it was found in the kurgans of old Turkish lords strengthen the thesis that it is a Turkish carpet. The Pazyryk Carpet is currently exhibited in the Hermitage Museum of Art and Culture in Saint Petersburg, Russia.
Keywords: Ancient Turks, Carpet, Weaving in Turks, Pazyryk Carpet, Turkish Red.

NATURAL BIOACTIVE SUBSTANCES WITH HYPOLIPIDEMIC AND HYPOTENSIVE THERAPEUTIC EFFECTS

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ABSTRACT

Nutraceutical products represent a new generation of food with high bioavailability of components, which is also the basis of a prevention strategy. They are beneficial to patients' health without being considered "drugs". The use of lipid-lowering nutraceuticals (and their combination) is supported by preclinical and clinical evidence of efficacy and safety. However, the use of nutraceuticals should not replace therapy with conventional drugs, when their prescription is indicated by therapeutic guidelines. It must be clearly emphasized that there are still no trial results demonstrating that nutraceuticals can prevent cardiovascular disease morbidity or mortality in a primary prevention setting. It is important to emphasize once again that nutraceuticals cannot replace lipid-lowering therapy, but could help to optimize it. Taking into account the influence of some of the presented nutraceuticals on different lipid parameters, it seems that this therapy may be particularly important to consider for: patients with mixed dyslipidemia, patients with diabetes, patients with low to moderate dyslipidemia, patients on statins. Associated side effects that cannot be treated with statins/adequate doses of statins and have a higher risk of cardiovascular events. However, the lipid-lowering effect of nutraceuticals is clinically relevant if sustained over the long term (years) and has a positive impact on cardiovascular risk factors.

Keywords: lipid-lowering effect, cardiovascular risk, cardiovascular disease, hypolipidemic, nutraceuticals.

YELLOW DYE PLANT IN THE EVALUATION OF MARGINAL AREAS: SAGE (*SALVIA* SP.)

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ABSTRACT

Sage (*Salvia* sp.) is a plant with a very high medicinal and aromatic value with its rich secondary metabolite content. Although the naturally found species in our country are common, medicinal sage (*S. officinalis*) is not available, but it is produced as a culture plant, especially in the Aegean region. Salvia species collected from nature and traded are generally Anatolian Sage (*S. fruticosa* Mill.) and Çalba (*S. tomentosa* Mill.). Salvia is used in foods and cosmetic products to give taste and aroma, as well as for decoration purposes. Sage production areas are close to marginal areas. It is possible to provide sustainable production of sage, which is a product whose cultivation is evaluated economically and with high added value, without harming the nature. For this reason, it is inevitable to prefer marginal areas as production areas. Sage, which has many different uses, especially its medicinal use, is also used as a dye plant. A light yellow (not very dominant) color is obtained by mordanting the leaves and stems with alum. In addition, black dye is can obtained by changing the mordant. It can be used dry or wet as a dye plant. There are also studies on its use as a food dye.

Keywords: Sage, Salvia, Yellow, Marginal Area, Dye Plant

DIFFERENT USAGE AREAS OF THE BLUE DYE PLANT (CICHORIUM INTYBUS L.)

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ABSTRACT

Chicory (*Cichorium intybus* L.) is a very valuable medicinal plant with various pharmacological activities such as antimicrobial, anthelmintic, antimalarial, hepatoprotective, antidiabetic, gastroprotective, anti-inflammatory, analgesic, antioxidant, antitumor, antiallergic. At the same time, blue chicory, which was introduced to the world as a forage plant in the 70s and whose varieties were developed, is a plant that draws attention with its natural spread and density on the earth. Blue flowers bloom in April-September. Chicory species naturally found in cultivated fields, meadows, rocky slopes and roadsides are used as a vegetable and coffee plant for human nutrition and as fodder for animal nutrition. It can produce large quantities of high quality forage under suitable conditions. The performance of chicory in animal nutrition is similar to that of leguminous plants. All parts of the plant are a very rich source of energy. Chicory seeds, aerial parts and roots contain significant amounts of mineral substances (Fe, Cu, Zn and Mn). Different parts of chicory also contain varying amounts of ascorbic acid, starch, tannins, reducing and non-reducing sugars. Chicory, which has many different usage areas, reduces nitrate leakage with its deep roots, thus reducing acidification and salinity formation. In recent years, the interest in the use of natural dyes in textile coloring has increased the interest and need for dye plants. Chicory is also a plant rich in natural dyes. Its leaves and root are used as a natural dye. In this study, the economically and culturally important usage potential of chicory, which has a rich traditional and scientific usage history and future, is discussed in detail.

Keywords: Dye plants, Cichorium, Blue, Forage, Medicinal

PROCESS AWARENESS FOR HOW TO OBTAIN A NON-MUTAGENIC MADDER ROOT (*RUBIA TINCTORUM*) EXTRACT FOR TEXTILE DYEING[1]

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ABSTRACT

Rubia tinctorum L. (madder) has a long history of use as a red dye. Madder extract is a complex mixture of metabolites in which anthraquinones are the coloring compounds (e.g. alizarin, the main dyeing compound). However, publications have cast doubt on the safety of madder. Some anthraquinones were found to react with deoxyribonucleic acid indicating possible mutagenic effects. Especially 1,3-dihydroxyanthraquinones, which were substituted on C-2 with a hydroxymethyl group on C-2, showed mutagenic effects (i.e. lucidin, ibericin) or with a methyl group after metabolic activation by S9 liver cells (e.g. rubiadin). In this research is shown that the presence of mutagenic compounds can be affected and even avoided by opting for certain choices in extraction and fractionation parameters. By choosing to stir in water first and then extract in an organic solvent an enzymatic cascade by two endogenous enzymes can make that mutagenic lucidin is absent or at least in a much less extent. And if no lucidin is present, the formation of mutagenic ibericin or any other mutagenic C-2 ether artefact, by using alcohol as extraction solvent is not possible. Further treatments are described and investigated. The level of mutagenicity can be reduced by using heat treatment which is common in industrial downstream processing such as in spray drying. Removal of the present rubiadin is possible by flash chromatography. The presence of no or at least below the detection limit of lucidin and rubiadin in artificial sweat and saliva extract of madder root dyed wool makes the human uptake of harmful anthraquinones by the skin unlikely. All madder root extracts made were tested for their mutagenic potential with the *Salmonella* microsome assay (Ames test) with the strain TA100. The test results are compared with the composition of anthraquinones analyzed by HPLC analysis.[1]

Keywords: *Rubia tinctorum* L., alizarin, lucidin, Ames-test, product process

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DETERMINATION OF GALLIC ACID BY HYDROPHILIC INTERACTION LIQUID CHROMATOGRAPHY

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ABSTRACT

Gallic acid (GA) is a secondary metabolite in polyphenol structure found in hardwood species such as oak, chestnut and in many plants such as tea, coffee, grapes and blackberries (1). GA is found in plants as free acids, esters, catechin derivatives and hydrolysable tannins. GA and its derivatives have antioxidant activities, cardiovascular and neuroprotective effects. Apart from its phytochemical role, İT is also used in tanning, ink dyes, and the manufacture of paper.

Hydrophilic interaction liquid chromatography (HILIC) is a variant of normal phase liquid chromatography that partly overlaps with ion and reversed phase liquid chromatography. Separation of the compounds were maintained on a polar (hydrophilic) stationary phase with reversed-phase type eluents. HILIC has been successfully applied to the separation of small and polar molecules (2).

A Simple, accurate and specific hydrophilic interaction liquid chromatography method was developed for the simultaneous determination of GA. The assay of the drugs were performed on a Ultisil HILIC Amid column (5μm, 3.0×150mm i.d.) with diode array dedector (DAD) detection at 272 nm. The mobile phase consisting of 0.1% o-phosphoric acid and methanol in the ratio of 70:30 (v/v), and a flow rate of 0,5 mL/min was maintained. The standard curve was linear over the range of 0,5-10,0 μg/mL and R^2 value is 0,9982. The proposed method was validated in terms of Linearity, Range, Accuracy, Precision and Specificity. Within-day and between day precision as expressed by relative standard deviation was found to be less than 2%. Proposed method was successfully applied for the estimation of GA in niozome formulations.

Keywords: Gallic acid, HILIC, DAD

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EVALUATION OF *RUBIA TINCTORUM* L. USAGE FOR FOOD COLOURING PURPOSES

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ABSTRACT

Colour is one of the most important sensory aspects of food products. In food technology, food colourants are added to food processes, to enhance or sustain the sensory characteristics of the food products, which may be affected or lost during processing or storage, and in order to retain the desired colour appearance. There is no doubt that it is technologically feasible to prepare natural colorants from locally known plants scientifically.

One of the local plants has colourant properties is *Rubia tinctorum L.* which is a madder from Anatolia. *Rubia tinctorum L.* plant is a species belonging to the *Rubia* genus of the *Rubiaceae* family. It is used generally for textile industry. Besides, the colour obtained by following a special method of dyeing cotton fiber with madder is called Edirne Red. However, there is not enough research on the applications of this plant in the food industry. For this purpose, it should be investigated to colour compounds composition, chemical reactions in processing and effects on health. The red colour obtained from the root shoots of madder is used as a food colouring in Japan for dishes, beverages, processed meats, sweets, and various food products. While the use of this colour is permitted in Korea, it is not allowed in the European Union and the United Nations. The colour obtained from madder root is red under neutral conditions but turns yellow under acidic conditions.

The root shoots contain glycosides that provide the colouring matter. These glycosides are hydrolysed as a result of enzymatic action, yielding alizarin and its derivatives along with glucose. The most important of these glycosides is ruberythrin acid. Ruberythrin acid yields alizarin and glucose. Purpurin glycoside yields purpurin and glucose, while rubiadin glycoside yields rubiadin and glucose. In addition to these, numerous other colouring agents such as pseudopurpurin, munjistin, and

xanthopurpurin (purpuroxanthin) can also be found. Various studies have identified 36 anthraquinones in madder. Among these, alizarin is the most significant. The presence of the compound lucidin restricts its use in food products because studies have shown that lucidin has mutagenic properties. Therefore, it is widely accepted that this plant is mutagenic in food products. *R. tinctorum* have revealed the presence of various quinonyl compounds in addition to lucidin. Studies have revealed that some qoinonyl compounds are genotoxic in both prokaryotic and mammalian systems.
Keywords: Natural Food Colourants, Edirne Red, *Rubia tinctorum* L.

USE OF NATURAL DYES IN THE RESTORATION AND CONSERVATION OF HISTORICAL TEXTILE WORKS

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ABSTRACT

Weaving, one of our traditional handicrafts that reflect our cultural heritage and identity, especially in terms of textile history, are important sources that enlighten us about the details of many disciplines such as technique, pattern, color and rope properties. These works convey and inform us about the culture of the society, its social and economic structure, and its fashion. All societies work and produce in order to maintain, enrich and further their existence. Throughout history, Turks have created traditions, artistic, ethnic and cultural riches and passed them on to future generations, starting from a small family unit and on their way to becoming a state. Historical and traditional textile works, which are a part of our cultural heritage, are concrete cultural examples.

Ethnographic and traditional textile works registered, protected and exhibited in the Beylerbeyi Sabancı Olgunlaşma Institute Museum inventory were handled with this approach. In practice, after taking microscopic shots of the work, acetate drawings of the deteriorations, mechanical cleaning applied, complementation and reconstruction processes applied to the damage and loss of parts over time help us to see the closest state of the work to its original state. Fethi Bey, who set out for Egypt with the plane he was on duty in 1914, when World War I started, was martyred when the plane crashed near Lake Tabariye in the Arabian Peninsula. Sadık and Nuri, who could not hear from their friends, were martyred when their plane crashed over the Taurus Mountains while they were going to Arabia to look for him. Within the restoration and conservation works of the beret with inventory number 0483052010, which is in the collection of the Istanbul Air Force Museum and worn by Sadık Bey, one of the first Turkish pilots, when he was martyred, raw silk weaving was used as an integral and complementary material, and after pre-washing and preparations, it was mordanted and mixed with madder (Rubia Tinctorium) plant in the Sabancı

Olgunlaşma Institute Natural Dyeing Laboratory. Fiber breaks, piece losses, surface pollution and staining were detected in the preliminary analysis on the beret made of wool material, measuring 41 cm x 27 cm.

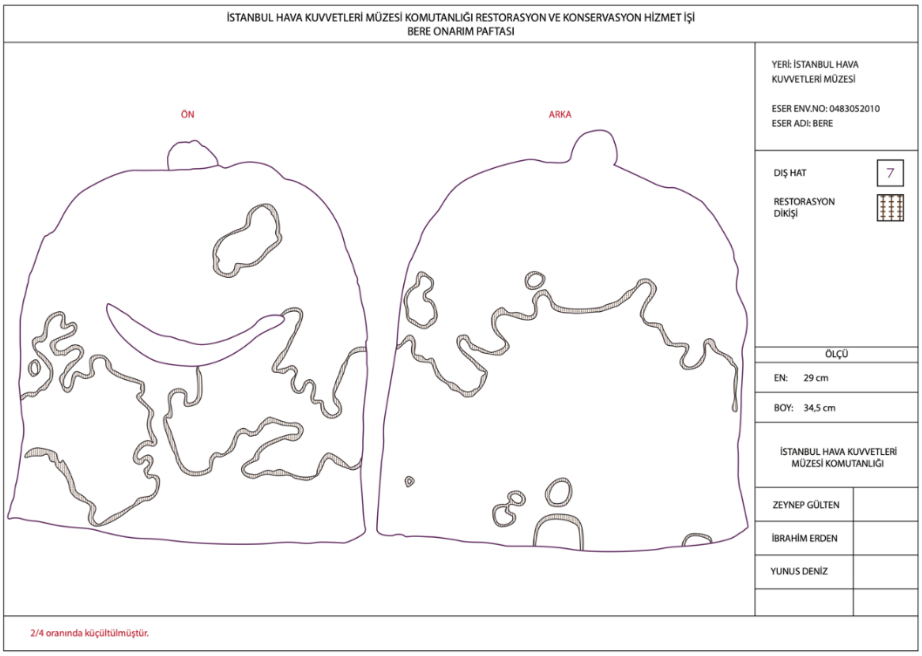

Figure 1. The sewing areas determined on the work that is the subject of the study

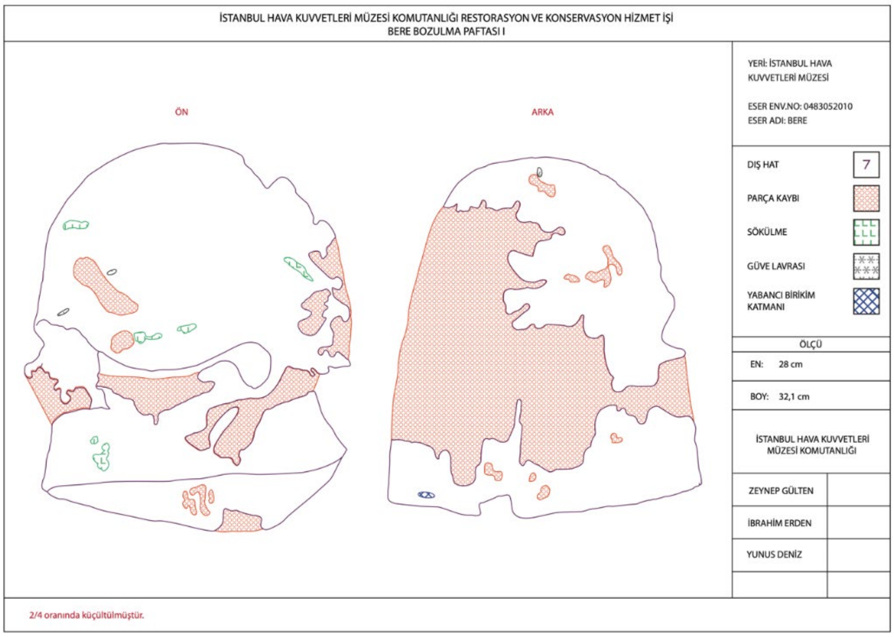

Figure 2. Model in which the areas to be restored are determined on the work that is the subject of the study

Due to its preservation in a closed area, deformation, biological degradation, mothiness and discoloration have been observed. After the deteriorations were identified and described, general and detailed photographs of the work were taken, technical drawings of the deteriorations were made, and the documentation work was completed. After the documentation phase was completed, mechanical cleaning was carried out. Cold steam impregnation technique was applied to the color lost artificially. A support mold was made suitable for the size of the work and it was allowed to dry in its own form. Conservation schools of countries and laboratories vary in the restoration and conservation of different types of artifacts. In order to ensure the continuity of the integrity of the form as a result of the restoration work on the woolen beret work studied, museum experts, expert conservators and restorers decided to fix the work on the support fabric.

It was deemed appropriate that the support fabric to be used was Ödemiş silk. Raw Ödemiş silk was pre-washed according to the appropriate liquor ratio and sericin was removed. As a result of color experiments, the appropriate tone was selected and the dyeing of the fabric was completed. It is important for portable ethnographic and archaeological textile artifacts, which have survived from past to present, to survive for a longer time and to be transferred and informed to future generations, with the necessary restoration work and completion of the stages for improvement and conservation. Inferring from the examples that were produced centuries ago with natural materials and correct methods and have survived to the present day, the quality of natural dyeing, the fact that it does not harm human health, is anti-allergenic and anti-bacterial, and innovation studies are carried out, and the use of natural dyes is more prevalent in wearable clothing and home textile designs. It will enable production and trade.

Keywords: Restoration, Conservation, Natural Dye, Madder, Textile Work, Museum

IDENTIFICATION OF DYER'S WOAD (*ISATIS* SP.) SPECIES DISTRIBUTED IN ISPARTA AND ITS SURROUNDINGS AND DETERMINATION OF THEIR DYESTUFF PROPERTIES

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ABSTRACT

This research was carried out to determine the morphological characters, dyeing characteristics and indigo contents of different *Isatis* species collected from different locations in Isparta province *(Isatis tinctoria, Isatis glauca, Isatis cappadocica*) and cultivated in the field of Isparta Applied Sciences University Agricultural Research and Application Farm (*Isatis tinctoria, Isatis floribunda, Isatis glauca*). In this study, it was determined that *Isatis tinctoria, Isatis glauca, Isatis cappadocica* species are present in the Göller Region. While *Isatis glauca* species collected from nature had higher values in terms of morphological characteristics, *Isatis tinctoria* species cultivated had higher values in terms of indigo content. According to the dyestuff analysis, the highest indigo content was found in cultivated *I. tinctoria* (2.26 mg/g), while the lowest indigo content was found in *Isatis glauca* and *Isatis cappadocica* (0.004 mg/g) collected from nature. As a result of dyeing with *I. tinctoria*, dark blue color was obtained and washing fastness value was determined in the range of 2-5. It is thought that more detailed studies should be carried out in the future.

Keywords*:* *Isatis tinctoria, Isatis floribunda, Isatis glauca, Isatis cappadocica*, Morphological proporties, Indigo content

DETERMINATION OF THE WOUND HEALING EFFECT OF WALNUT PULP WASTE IN RATS

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ABSTRACT

Today, many problems such as skin disorders, dermatological diseases, especially cuts and injuries due to bacterial, fungal and viral factors are increasing day by day. Due to the side effects, cost and resistance development potential of drugs, creams and ointments used in the treatment of these diseases, alternative treatment methods are being investigated. In this context, walnut plant (*Juglans regia* L.) plays an important role in the treatment of eczema, wounds and skin diseases due to its antibacterial, antifungal and antiviral, wound healing and tissue repairing effects. The aim of this study is to determine the wound healing effect of Juglans regia L. pulp in topical application on rats. In the study, the wound healing effect of cream formulations prepared by adding walnut pulp extract (0%, 25%, 50%) was examined in rats. Wound size and tissue examination were performed to evaluate wound healing. No rat died during the experiment and wound healing was faster in the walnut pulp cream treated groups. Statistically significant differences were found between the groups in terms of histopathologic and histochemical parameters ($p < 0.01$). Wound diameter in mice was reduced to 420.28±37.46 mm and 336.28±21.66 mm with creams containing 25% and 50% extracts, respectively. Compared to the control group (578.85±27.23 mm), these values show that the extract increased the wound closure feature in a dose-dependent manner. Therefore, the addition of 50% extract was determined as the most effective application for wound healing. This study is of great importance in terms of both the utilization of waste and the scientific characterization of the knowledge in traditional medicine.

Keywords: Healing, Rat, Walnut, Natural Dye Plant

DETERMINATION OF THE WOUND-HEALING EFFECT OF A CREAM WITH MADDER EXTRACT IN RATS

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ABSTRACT

Madder (*Rubia tinctorum*) is a perennial dye plant belonging to the *Rubiceae* family. This valuable plant is used as a source of medicine, cosmetics and dyestuffs. Thanks to the bioactive active molecules that increase the importance of the plant, it has also gained a place as a wound healing plant in Turkish traditional medicine. The aim of this research was to reveal the wound healing effect of Rubia tinctorum plant. For this purpose, the wound healing effect of the ethanol extract obtained by subjecting Rubia tinctorum plant to Soxhlet extraction was examined in mice. The mice were randomly divided into 7 groups and creams with 0.25%, 0.5% and 1% extract were topically treatmented to the mice. The experimental period was 15 days, applications were made once a day, progressive changes in the wound area were observed daily and the wounds were measured every 3 days. As a result of the findings obtained, statistically significant differences were observed in terms of histopathological and immunohistochemical properties in parallel with the dose increase ($p < 0.01$). While the wound diameter was 3.93±0.06 in the control group, it was 3.42±0.12 and 2.87±0.08 at 0.25% and 0.50% doses, respectively. This study demonstrates that the madder plant has a potential application area in the cosmetic industry. However, there is a need for more detailed researches on the use of madder in cosmetics.

Keywords: *Rubia tinctorum*, wound healing, root dye cream, cosmetics, natural dye