



Usability of Essential Oil Extracted Plant Pulp in Screen Printing in The Context of Sustainability

Sürdürülebilirlik Bağlamında Uçucu Yağı Alınmış Bitki Posalarının Serigrafi Baskıda Kullanılabilirliği

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ABSTRACT

Problem statement; The main purpose of the study, "Usability of de-Essential Plant Pulp in Textile Printing in the Context of Sustainability", is to reveal the industrial use of natural dyes in the textile printing sector. During the preliminary evaluation process, it was seen that screen printing as a printing method has significant advantages for the industrial integration of natural dyes. Based on this, as a result of the applications and analyzes carried out with the experimental research method, it has been revealed that the use of natural dyes on an industrial scale will be possible by transferring the natural dye obtained from plant pulp with essential oil removed to the textile surface with the screen printing technique and ensuring sufficient fastness. In this study, it is aimed to present screen printing as an alternative to traditional fabric printing techniques, as well as to make positive contributions to sustainability by using natural dyes obtained from plant pulp. This increases the importance of the study. As a result, it has been observed that natural dyes obtained from plant pulp with essential oils removed can be transferred to the fabric by screen printing technique, and the pre-mordanting process and fixing in salt water increase the washing and rubbing fastness values. Apart from all these, three new emulsion-free printing techniques have been developed, independent of the emulsion printing technique applied as standard in screen printing technique.

Keywords: Sustainability, naturel dye, plant pulp, silkscreen printing

Öz

Problem cümlesi; "Sürdürülebilirlik Bağlamında Uçucu Yağı Alınmış Bitki Posalarının Tekstil Baskıda Kullanılabilirliği" olan çalışmanın temel amacı, doğal boyaların endüstriyel olarak tekstil baskı sektöründe kullanılabilirliğini ortaya koymaktır. Yapılan ön değerlendirme sürecinde baskı yöntemi olarak serigrafi baskının doğal boyaların endüstriyel entegrasyonu için önemli avantajlarının olduğu görülmüştür. Buradan hareketle, deneysel araştırma yöntemi ile gerçekleştirilen uygulamalar ve analizler sonucunda, uçucu yağı alınmış bitki posalarından elde edilen doğal boyanın serigrafi tekniği ile tekstil yüzeyine aktarılması ve yeterli haslığın sağlanması ile doğal boyaların endüstriyel boyutta kullanımının mümkün olacağı ortaya çıkmıştır. Bu çalışmada serigrafi baskının geleneksel kumaş baskı tekniklerine bir alternatif olarak sunulmasının yanı sıra bitki posalarından elde edilen doğal boyaların kullanımını ile sürdürülebilirliğe olumlu katkılar sağlanması da amaçlanmıştır. Bu da çalışmanın önemini artırmaktadır. Sonuç olarak, uçucu yağı alınmış bitki posalarından elde edilen doğal boyaların serigrafi tekniği ile kumaşa aktarılabilirdiği, ön mordanlama işleminin ve tuzlu suda sabitleme işleminin yıkama ve sürtünme haslık değerlerini arttırdığı görülmüştür. Tüm bunların dışında serigrafi baskı tekniğinde standart olarak uygulanan emülsiyon baskı tekniğinden bağımsız üç yeni emülsiyonsuz baskı tekniği geliştirilmiştir.

Anahtar Kelimeler: Sürdürülebilirlik, doğal boya, bitki posası, serigrafi baskı

Introduction

In the latter half of the 18th century, the widespread adoption of a capitalist economy due to the Industrial Revolution ushered in a new world order that altered conceptions of humans, nature, and the universe. Unfortunately, this new order has also engendered manifold threats to our environment, including increased waste, depleted natural resources, species extinctions, ozone depletion, environmental pollution, climate change, and ultimately harm to ecosystems. The textile sector, the first application area of the Industrial Revolution, is viewed as the primary contributor to these issues. Over time, the harmful impacts of excessive use of natural resources and chemicals have been brought to light by consumers and international organizations. Environmentalism, ecology, and sustainability approaches have become more prevalent and have expanded to encompass the textile industry in various

parts of the world. The literature addresses sustainability in the textile sector through various concepts, including “textile ecology, ecological sustainability, sustainable design, sustainable fashion, slow fashion, slow design, and green production”. However, the industry’s production practices in areas such as raw materials, yarn, weaving, knitting, pre-treatment, dyeing/finishing, printing, apparel, and fashion fundamentally contradict the ecological sustainability approach.

In this context, sustainability is a multifaceted concept and phenomenon encompassing ecological, economic, and social dimensions. It encompasses our relationships with ourselves, society, and institutions, surpassing our relationship with the environment. Sustainability involves ecological, economic, and sociopolitical dimensions that intersect nationally and globally, as well as environmental dynamics affecting human livelihood and well-being (Joy, Sherry et al., 2012, p. 274- 275). To gain a comprehensive understanding of the fashion industry’s impact on the environment and public health, as well as the extent of production and consumption, it is necessary to examine key numerical data. According to relevant sources, both polyester and cotton production and clothing consumption have steadily risen since 1990, with the fashion industry contributing to an increase in carbon emissions and biodiversity loss (Palm et al. 2021, p. 2). In Bursa Province Textile Recycling Facility Pre-Feasibility Report (2021), around 1,155,000 tons of textile waste is generated annually in Turkey and according to waste collection statistics, 3% of the total waste is textile waste and approximately 2,500 tons per day used clothes and textiles go to landfill without being processed. In the same report, it is predicted that if the current production and consumption conditions continue, the textile sector alone will consume 26% of the world’s carbon budget by 2050. In addition, scenarios prepared assuming that the current conditions will continue predict that the use of non-renewable raw materials by the textile and ready-to-wear sector will reach 300 million tons in 2050 and the amount of microplastics released into the oceans will reach 22 million. If Turkey were to recover its discarded polyester and cotton products, it could generate about 13.1 billion kwh of energy from cotton and 14 billion kwh from polyester (Altun, 2014, p. 11- 15). The industry’s impact involves producing over 92 million tons of waste and consuming around 79 trillion liters of water yearly, according to recent data. Based on the environmental impacts, a shift to sustainable practices throughout the supply chain and changes in consumer behavior are imperative to slow down production (Ninimaki et al., 2020, p. 189).

Over time, the public has become increasingly aware of the negative impact of chemicals and synthetic dyes, resulting in a push for the resurgence of natural dyes. Despite this, the industrial application of natural dyes within the sector remains challenged by complexity. The use of natural fibers, fabrics, and dyes is important for the overall sustainability of human ecology. The use of natural raw materials, as opposed to synthetics, is a fundamental principle of ecological sustainability. However, utilizing these raw materials in their natural state within the industry contradicts sustainability philosophy and poses a serious paradox, leading to the depletion of nature’s limited resources. In the current conjuncture, the solution to this problem is considered to be the reuse of plant pulps from which essential oil has been extracted.

Until the 1850s, almost all dyes were derived from natural sources (Morris and Travis, 1992). The use of natural dyes for textile dye-

ing has declined drastically after the discovery of synthetic dyes in 1856 (Arora, Agarwal, and Gupta, 2017, p. 35- 36). After the discovery and commercialization of synthetic dyes by Henry Perkin in 1856, the consumption of natural dyes decreased significantly. However, the increase in environmental awareness of people in recent years has increased the use of natural dyes in the textile sector. The toxic and allergic effects of synthetic dyes lead people to natural dyes. The strict environmental standards applied in textile and ready-made clothing by countries that are cautious about the protection of nature and human health revive the interest in natural dyes in the coloring of textile materials (Gupta, 2019).

Today, approximately 10,000,000 tons of synthetic dyes are used annually, the production and application of which causes serious health hazards and harms the ecosystem of nature (Iqbal and Ansari, 2014: p. 683). The textile industry continues to search for an economical solution to treat (decolorization) the nearly 200 billion liters of colored wastewater produced annually. Countries, states and industries spend billions of dollars on pollution reduction research and construction of wastewater treatment facilities (Kant, 2012, p. 24). The production of synthetic dyes is energy intensive. Many of these dyes, especially the azo-based ones, are known to be carcinogenic (Prabhu and Aniket, 2012; Gita, S., Hussan, A., & Choudhury, T. G. 2017; Kant, 2012). Currently, all non-environmentally friendly synthetic compounds are used for dyeing textile materials. They are not biodegradable, carcinogenic and create waste disposal problems as well as water pollution. Natural dyes offer a reasonable solution to these problems (Arora, Agarwal and Gupta, 2017, p. 37).

Natural dyes; It is obtained from natural sources such as plants, animals, minerals and microorganisms. The toxicity, carcinogenicity and allergic reactions of synthetic dyes have increased the interest in natural dyes (Karuna, Pankaj and Singh, 2019, p. 87).

- Some advantages of natural dyes: (Gupta, 2019, p. 1-2)
- They do not create any health hazards.
- It has easy extraction and purification properties.
- They have high sustainability.
- They have light dyeing conditions.
- They can be adopted from renewable sources.

Based on all these mentioned; The problem statement/topic of the related study has been determined as “The Usability of Plant Wastes in Screen Printing in the Context of Sustainability”. The aim of the related study is to develop a technique with the help of screen printing in order to apply the printing processes, which are currently done with traditional methods, on an industrial scale in the sector. In case the natural dye is transferred to the textile surface with the screen printing technique and sufficient fastnesses are provided, it will be possible to use the natural dyes in the printing sector on an industrial scale. Natural dyeing and printing have been used by human beings for centuries with traditional methods. In the current study, it is aimed to accelerate the slowness of traditional printing techniques by means of serigraphy and thus to make positive contributions to both the sustainability of nature and human health. On the other hand, the fact that the most suitable method for the industrialization process of natural dye has been determined as a screen printing technique

as a result of related researches and experiments has determined the course of the application area of the relevant subject.

Conceptual Framework

Screen printing technique

When the developmental stages of printing techniques are analyzed, they date back to the ancient times. The first printing samples were functional and aimed to ensure the continuation of people's communication, information and culture (Demir, 2012: p. 74). In the modern age, technological developments, which are effective in all value structures from culture to art, have affected almost all social structures (Ateş, 2016, p. 76). This rapid development has brought many negativities along with facilitating human life (Keskin, 2016, p. 55). When we look at the issue on a sectoral basis in terms of textile dyeing and printing, the result is not very different.

It is very difficult for natural dyes and prints made with traditional methods to find a presence in the sector, which acts with the logic of fast production. In case the natural dye is transferred to the textile material with the screen printing technique and sufficient fastnesses are provided, it will be possible to use the natural dyes on an industrial scale in the sector. In this case, positive contributions will be made to both human health and the world ecosystem. At this point, the harmful effects of the chemicals used in the sector have been revealed as a result of many researches. In order to eliminate or at least reduce these harmful effects, it is necessary to reduce the use of synthetic substances and return to the natural one. In order to be a pioneer in the world arena by bringing together the methods and techniques existing in our cultural infrastructure with the opportunities of the age, serious studies should be carried out at the point of ecological applications. The process of transferring the ink (dye) to the printing material by passing it through the exposed (processed) parts of the sieve (gaze) is called screen printing. The sieve made of silk or polyester materials stretched over a metal or wooden frame, made of paint-permeable and impervious surfaces, is used by taking a printing medium. The dye on the printing surface is transferred to the printing material under the sieve with a rubber tire (squeegee) (Sözen, 1993). In general, serigraphy; It can be defined as the process of printing on the surface to be printed with the help of an apparatus by leaving the parts corresponding to the pattern exposed with the help of a template on which a perforated woven surface (silk, polyester or metal woven) is stretched. The screen printing technique is also called the "silk printing" technique in short (Biren, 1992). With the development of technology over time, synthetic weaving materials have started to be used instead of natural silk. In screen printing, the screen (template), which is formed from the surfaces that pass the dye on the woven cloth and prevent the dye from passing, is used as a printing tool. Template preparation methods; It can be counted as sticking with glue, lacquer, posing with film and exposure of a gelatin layer with photomechanical copy (Biren, 1992, p. 3-4).

Screen printing can generally be divided into artistic and industrial purposes. In artistic screen printing; painters, graphic designers, print artists etc. They use this technique to reproduce their works. For industrial purposes, screen printing is commonly utilized in various industries and advertising. It is commonly seen in packaging, ceramics, textile factories, and electronics. Screen printing is also widely used in the advertising sector for different

purposes such as creating promotional signs, reproducing pictographic signs, and designing spaces (Tepecik, 2002, p. 111).

Tools and equipment used in screen printing

Tools used in screen printing technique; They can be listed as sieve (gaze), frame, emulsion, template, photo template, film, scraper (ragle), ink (dye), thinner and cleaner (Pekmezci, 2001). Scraper (ragle) is the most basic tool of screen printing. The squeegee ensures that the dyestuff spreads through the sieve and passes onto the printing material from the areas left open in the stencil (Bayram, 2019, p. 21). In textile prints, it should be preferred that the scraper (ragle) to be used has a full round rim. This profile gives good results on surfaces that are very absorbent and require more dye (Üneş, 2019, p. 49). The squeegee used in screen printing must be made of a natural and synthetic rubber. Scraper (ragle) should be checked at regular intervals. It should be cleaned after printing in order to prevent stains and scratches on the surface of the squeegee. Sharp and clean edges affect the print quality. Scraper (ragle) should be neither too hard nor too soft. While a very hard squeegees the silk, a soft squeegee cannot provide the proportional distribution of the dye on the printing surface due to the angle distortion (Duran, 2019, p. 26). The squeegee should be chosen according to the size of the pattern. The dye is poured onto the sieve and then pulled through with a squeegee. The squeegee should be held at an angle of 45-70 degrees and with appropriate pressure. Ensure all fingers of the hand can grip the squeegee in a single motion (Acar, 2012, p. 27).

Scraper (ragle); It is a tool made of thin, flexible rubber or rubber material with a wooden or metal handle. Wrong squeegee selection causes darkening, loss of detail and excessive dye consumption. When selecting a blade, it is important to consider the hardness of both the tire and the rim profile. The hardness degrees of tires are indicated by the letter A and are expressed in durometers. Durometer value corresponds to 60A soft, 70A medium, 80A hard and 90A super hardness. The degree of hardness of the scraper (ragle) should be determined according to the design and the surface. When printing on a rough surface, like fabric, and with a loosely woven silk screen, it is best to use a squeegee between 60A and 70A. On the other hand, if the material to be printed has a smoother structure and a densely woven sieve, a harder squeegee between 80A and 90A should be used. To achieve a quality print, it is advisable to use different squeegee blades based on the color and detail of the pattern to be printed (Esen and Gündoğdu, 2021, p. 422-424). The squeegee angle is very important. As the angle of the squeegee to the vertical plane decreases, the contact surface of the squeegee decreases, dye holding ability and dye transfer decrease (Şahinbaşkan, 2009, p. 28). Screen selection should be based on the characteristics of the print, the surface structure, and the type of dye used. As a result, a code system has been developed for screens. To simplify screen selection, a code system has been implemented wherein numbers indicate the number of yarns within 1 cm² of the screen (Togay, 2005: 200). Sieves are composed of frames and sieve When selecting a sieve, the decision should be based on variables such as the size of the particles in the dye and the type of template to be utilized. Professional inks generally have very fine particle structure and are used on very fine silks. Water-based inks can show the most detail (Duran, 2019, p. 24- 25). The origin of silk screens is human hair, which was used by the Japanese. Patterns were obtained by sticking motifs cut from paper under this weaving, which was cre-

ated with human hair (Acar, 2012, p. 23). Sieve types are divided into three categories: silk weaving, synthetic weaving, and metal weaving (Duran, 2019, p. 23). Synthetic woven screens are divided into two groups as polyamide and polyester. Polyester webbing is preferred for its high dye permeability, chemical resistance, ease of cleaning, tensile strength, and affordability. Silk screens are well-suited for screen printing due to their color permeability, strength, and wide area. Additionally, metal screens like stainless steel are highly resistant to strong printing ink alkalis. The sieve number refers to the number of yarns per 1 cm² in weaving and is indicated by numbers from 43 to 200. As the number of threads in the weaving increases (the larger the sieve number), the thread diameter decreases. As the number of threads increases, the thickness of the thread increases; as a result, the area with dye permeability decreases and the thickness of the dye increases (Yazgaç, 2013, p. 42- 48).

Screen printing preparation processes (emulsion, template and exposure)

In serigraphy; The sieve stretched on a wooden or metal frame is covered with a film layer called emulsion and exposed in the light according to the desired pattern. Next, water is used to empty the photosensitive areas and form a template. This process, referred to as template or mold preparation, involves creating areas on the surface that are either paint-permeable or impermeable. First of all, the pattern to be exposed to the film should be prepared with the help of computer programs or by hand drawing and printed on acetate or tracing paper. In serigraphy; The number of colors in the pattern should be determined and a separate film should be prepared for each color. Each film should be posed separately on sieves and printed according to the color order (Yazgaç, 2013, p. 80). In screen printing, light sensitive emulsion should be applied with a thin layer on the sieve and then exposure should be done. Emission sieve is kept in a dark room or drying cabinet to dry. It is then exposed to a sieve film and converted into a hardened film. The figure must be transferred onto a transparent material like acetate or tracing paper. The pattern printed on a transparent material (acetate, tracing) should be fixed on the glass of the exposure table and the emissive sieve should be placed on the pattern. At the exposure table, opaque areas on transparent materials do not reflect light, while transparent areas allow it to pass, resulting in these areas becoming hard. After the exposure, the places that do not receive light, that is, the pattern, are opened by washing with water. To ensure successful exposure, a 250-watt light bulb should be placed in the center of the sieve and the exposure should be conducted. During this process, it should be ensured that the electrical equipment is porcelain or heat-resistant material (Yazgaç, 2013, p. 48). Washing should be done immediately after the exposure process. Water must be sprayed onto the sieve with sufficient pressure to reveal the pattern and form the pattern. Too much pressurized water can break the template. Drying both the emulsion and the sieve after bathing in an extremely hot environment damages the material.

Material and Method

In order to obtain the natural dye to be used in screen printing, dried and ground thyme(*origanum onites*) and sage(*salvia tomentosa*) plant pulps were obtained from the Antalya region. Essential oil extracted plant pulps were used to obtain natural dyestuff. Thyme and sage plants, which are among the medicinal and aromatic

plants, are collected by İnan Tarım ECODAB to extract essential oil and after the oil extraction process, dried and ground plant pulps (wastes) are used in different sectors. Since the essential oil extraction process of the plants obtained from İnan Tarım ECODAB is carried out by steam extraction method, the dyestuff content of the plant is sufficient for the dyeing process (Tekler, 2012, p. 2016).

Advantages of plant pulps:

- Can be used in dye-printing for 4 seasons
- Reaching the same or very close color tones every time
- Facilitating industrial production
- Reducing the consumption of the limited resources of nature
- Supporting sustainability
- Accessibility, storage and ease of use

Various methods exist for extracting natural dyes from plants, yet this study preferred boiling them in water. This method was preferred since it was evaluated that it would be possible to make the dyestuff dissolved in water suitable for use in screen printing with less material usage. As will be explained in detail in the following sections, the amount of dye plants determined as a result of preliminary studies were boiled in 750 ml- 1000 ml water for 20-30 minutes. The dye extracted from the boiled plant underwent filtration through a single or double layer of muslin to eliminate impurities. The liquid dye, which was subjected to boiling and separation from foreign substances, was then modified for screen printing through the addition of guar gum, a thickening agent that brings the dye to the desired consistency. Furthermore, gum arabic was incorporated into the dye to enhance its fastness properties.

In addition, the type and number of sieve used in screen printing is also very important. The sieve number refers to the number of yarns per 1 cm² in weaving and is shown in numbers from 43 to 200. As the number of yarns in weaving increases (the larger the sieve count), the diameter of the yarn decreases. As the number of yarns increases, the thickness of the yarn increases; as a result, the dye permeable area decreases and the thickness of the dye increases. Therefore, the screen number to be used in textile printing should be kept low. Metal, synthetic and silk materials can be used as sieves. In the thesis study, "silk sieve number 43" was preferred.

After the printing processes on the fabric, rubbing and washing fastness tests were applied and the results of the fastness tests with ISO 105 A03 gray scale were evaluated.

Pattern design, template, exposure

In order to set an example for the professional pattern exposure process in serigraphy; It was thought that it would be appropriate to choose stamp seals, which were similarly used for patterning textile surfaces 8000 years ago in Çatalhöyük. Inspired by the stamp seal finds from the Çatalhöyük excavations, which was determined as the theme, a pattern was stylized. (Bkz. Figure 1-2-3).



Image 1.

A stamp seal found in Çatalhöyük (Türkcan, 1992)



Image 2.

Stylized patterns from Çatalhöyük stamp seal



Image 3.

The pattern is exposed to the screen printing mold

Fabric and dye preparation

Silk and cotton fabrics made of 100% natural fibers of both vegetable and animal origin were favored for screen printing. Prior to printing, the fabric underwent purification and mordanting processes for preparation.

The purification process separates sericin in silk, lanolin substances in wool, and the size (haşıl) of cotton fabrics. Distinct purification techniques are preferred for vegetable and animal fabrics. Since animal fibers are more susceptible to sudden temperature changes and high temperatures (Cermikli, 2019, p. 14), it is important to handle them with care. It is crucial to follow these steps to ensure optimal purification results. For the purification process, cotton fabrics were washed in a washing machine with natural laundry detergent at temperatures ranging from 60°C to 90°C. Silk fabrics, on the other hand, were soaked in tap water for 24 hours and then hand washed.

The process of attaching metal or metals or substances to textile fiber is called mordanting, and the substances used for this purpose are called mordant substances. As mordant materials, water-soluble metal salts can be used, as well as materials with weak acid or base properties. Some mordant substances; alum [KAl(SO₄)₃·12H₂O], iron alum (FeSO₄·7H₂O), copper alum (CuSO₄·5H₂O), SnCl₂·2H₂O and wine stone (Karadağ, 2007, p. 12).

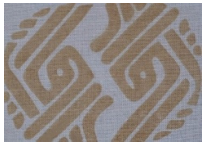
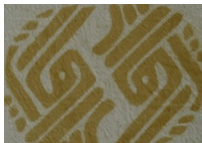
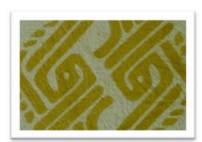
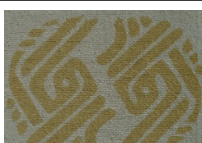
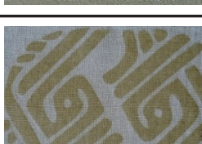
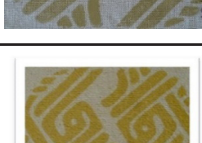
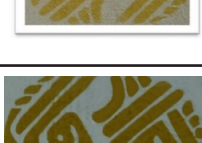
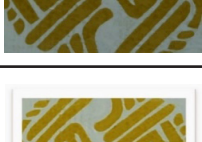
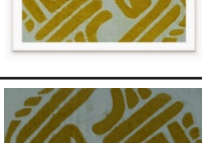
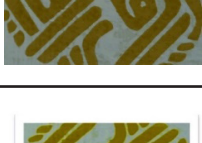
Mordanting process can be done in three different ways: before dyeing (pre-mordanting), simultaneously with dyeing (simultaneous-mordanting) and after dyeing (post-mordanting). In the study, pre-mordanting method was chosen to ensure that the fabrics are ready to receive the dye at the printing stage. Alum at the rate of 20% of the fabric weight was first dissolved in 500 ml of hot tap water and then added to the mordant bath for mordanting. The cotton fabrics were kept in a mordant bath at 100°C for 1 hour. On the other hand, silk fabric was mordanted at 50°C – 55°C temperature. The fabrics were then soaked in a mordant bath for 24 hours. The fabrics removed from the mordant bath were rinsed again in tap water and left to dry.

The dye obtained from the plants, which is boiled in tap water for 30 minutes, is filtered through a single layer of muslin in order to purify it from possible foreign substances. After the filtration process, the dye was brought to the consistency to be applied in printing with auxiliary substances as shown in the tables.

Screen printing applications

Screen printing applications were applied to the mordantized fabrics both wet and dry. After the printing process, the printed materials were left to dry for 1 day and then ironed for fixation. The ironing process can be repeated at different times. The printed fabrics were then washed with washing soda or natural detergent. After all these processes, the friction and washing fastness tests were carried out at Tirebolu IL-CA Herbal Products R&D Production Facilities.

All printing experiments were classified as fabric type, dye plant and amount, mordanting method and materials, auxiliary ingredients and amounts and fixation in Table.1.

| Table.1: Procedure and details about application of screenprinting | | | | | | | |
|--|------------------------|--|---|-----------------|---|--|---|
| App. Number | Fabric | Dye Plant and amount | Mordanting | Amount of Water | Auxiliary Ingredients and amounts | Fixing | Application of Printing |
| 1 | 100% Cotton (American) | Thyme (<i>origanum onites</i>) 30 g | No mordanting | 750 mL | Guargum (3 g) | The fabric is left for at least 24 hours and ironed occasionally |  |
| 2 | 100% Cotton (american) | Thyme (<i>origanum onites</i>) 30 g | Pre-mordanting 20% alum for 1 hour at 100 °C | 750 mL | Guargum (3 g) | The fabric is left for at least 24 hours and ironed occasionally |  |
| 3* | 100% Cotton (american) | Thyme (<i>origanum onites</i>) 30 g | Pre-mordanting 20% alum for 1 hour at 100 °C | 750 mL | Guargum (3 g), gum arabic (4 g), sea salt (5 g) | 24 hours after the printing process, ironed occasionally and then soaked in water with sea salt added for 2 hours. |  |
| 4 | 100% Cotton (american) | Sage (<i>salvia tomentosa</i>) 30 g | Pre-mordanting 20% alum for 1 hour at 100 °C | 750 mL | Guargum (3 g) | The fabric is left for at least 24 hours and ironed occasionally |  |
| 5 | 100% Cotton (american) | Sage (<i>salvia tomentosa</i>) 30 g | No mordanting | 750 mL | Guargum (3 g) | The fabric is left for at least 24 hours and ironed occasionally |  |
| 6* | 100% Cotton (american) | Sage (<i>salvia tomentosa</i>) 30 g | Pre-mordanting 20% alum for 1 hour at 100 °C | 750 mL | Guargum (3 g), gum arabic (4 g), sea salt (5 g) | 24 hours after the printing process, ironed occasionally and then soaked in water with sea salt added for 2 hours. |  |
| 7 | 100% Silk | Thyme (<i>origanum onites</i>) 30 g | Pre-mordanting keeping the fabric in 20% alum dissolved in tap water at 50°C – 55°C | 750 mL | Guargum (3 g) | The fabric is left for at least 24 hours and ironed occasionally |  |
| 8* | 100% Silk | Thyme (<i>origanum onites</i>) 30 g | Pre-mordanting keeping the fabric in 20% alum dissolved in tap water at 50°C – 55°C | 750 mL | Guargum (3 g), gum arabic (4 g), sea salt (5 g) | 24 hours after the printing process, ironed occasionally and then soaked in water with sea salt added for 2 hours. |  |
| 9 | 100% Silk | Sage (<i>salvia tomentosa</i>) 30 g | No mordanting | 750 mL | Guargum (3 g) | The fabric is left for at least 24 hours and ironed occasionally |  |
| 10* | 100% Silk | Sage (<i>salvia tomentosa</i>) 30 g | Pre-mordanting keeping the fabric in 20% alum dissolved in tap water at 50°C – 55°C | 750 mL | Guargum (3 g), gum arabic (4 g), sea salt (5 g) | 24 hours after the printing process, ironed occasionally and then soaked in water with sea salt added for 2 hours. |  |

Alternative approaches in screen printing technique

The process of transferring the ink (dye) to the printing material by passing it through the exposed (processed) parts of the sieve (gaze) is called screen printing. In this process, the screen printing sieve should be covered with emulsion and the pattern should be exposed to the sieve. As an alternative to this process, techniques have been developed in related study; artistic works, etc. to speed up the process, increase practicality and reduce costs for boutique works. In these techniques, the desired pattern can be transferred to the screen without the need for emulsion and exposure.

In the first technique; the pattern, drawn by hand or transferred with the help of computer programs on any surface like paper is emptied and is fixed on the sieve and made ready for printing. Tape, which is frequently used in screen printing and does not damage the sieve, for fixing process can be used. In addition, the paper on which the design is transferred must be strengthened and reinforced. The reason for strengthening is to ensure that the prepared template has a long life. For reinforcement, fabric, tape and so on depending on preference materials can be used.

To be used in this technique, a leaf motif was used based on the philosophy of sustainability. The dye used in printing is obtained from the sage (*salvia tomentosa*) plant. 100% natural cotton fabric was used as the printing material (Bkz. Figure 4).



Image 4.
Pattern fixed on screen printing sieve/ Screen printing processes/ Printed cotton fabric

In the second technique, unlike the first one, the area around the pattern is emptied, not the inside. In this technique, the method of fixing the pattern to the sieve changes as the area where the dye will pass onto the printing material changes. In this method, paper etc. prepared as a pattern template the material is fixed to

the sieve after the first printing and there is no need for any additional gluing process.

Inspired by the Çatalhöyük stamp seal finds, a pattern was stylized to be used in this technique. The dye used in printing is obtained from the sage (*salvia tomentosa*) plant. 100% natural silk fabric was used as the printing material (Bkz. Figure 5).



Image 5.
A stamp seal found in Çatalhöyük/ Stylized pattern/ Pattern fixed on screen printing sieve/ Screen printing processes/ Printed silk fabric

In the third technique; such as waste threads and fabrics with the help of the pieces, the desired or a random pattern is created. In this technique, it is seen that the waste materials are fixed on the screen printing mold from the first print without the need of any adhesive.

The pattern was created inspired by the Çatalhöyük stamp seal finds. The dye used in printing is obtained from the thyme plant. 100% natural cotton fabric was used as the printing material (Bkz. Figure 6).

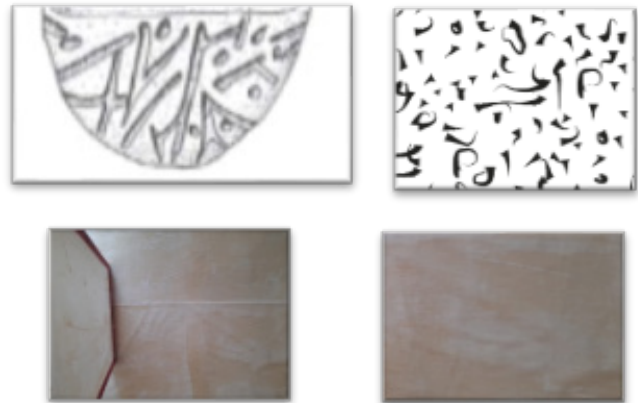


Image 6.
A stamp seal found at Çatalhöyük/ Pattern inspired by stamp seal/ pattern fixed on screen printing sieve/ Screen printing processes/ Printed cotton fabric

Fixation

After printing, the fabric was left to dry for at least 24 hours. Then, the fixation process was carried out by ironing the printed area on the reverse side or by placing a fabric on it in a steam manner. After this process, a permanent bond is formed between the dye molecules and the mordant we apply to the fabric. In order for this bond to become more permanent, waiting for about 1 week before washing will give healthier results. The ironing process can be repeated occasionally. In addition, to increase the fastness the printed fabrics were soaked in water with added sea salt for 2 hours after waiting for 24 hours.

Findings

Fastness Tests

Sample dyes for washing and rubbing fastness tests were made with the same recipes. The sample fabrics were washed at 40°C with detergent. A total of 10 printed samples were subjected to the fastness tests, but only the fastness values of the samples (numbered 3-6-8 and 10) with suitable results are presented in Table 2. The results of the fastness tests with ISO 105 A03 gray scale used in dyeing evaluation are given in Table 2.

Table.2. Fastness values of washing and rubbing tests

| Print no | Fabric | Waste of Plant | Washing | | Rubbing | |
|----------|--------|-------------------------|----------|-----------------|---------|-----|
| | | | Staining | Change in color | Wet | Dry |
| 3 | Cotton | <i>Origanum onites</i> | 3 | 1/2 | 4/5 | 4/5 |
| 6 | Cotton | <i>Salvia tomentosa</i> | 3 | 1/2 | 5 | 5 |
| 8 | Silk | <i>Origanum onites</i> | 4/5 | 4 | 5 | 5 |
| 10 | Silk | <i>Salvia tomentosa</i> | 5 | 4 | 5 | 4/5 |

A large number of samples were carried out and the samples from which the most suitable results could be obtained were subjected to fastness tests. The results of washing and rubbing fastness of the printed fabrics are shown in Table 2. There are two important points regarding the content of prescriptions. The first of these; arabic gum, which was not used in the first sample but was added to the dye later, and the second one; After all the waiting and ironing processes are finished, the samples are kept in water with added sea salt for 2 hours. With these two processes, fastness tests have increased to an acceptable level.

Cotton fabric samples have very low washing fastness values 1/2 change in color and 3 on staining. However, samples' rubbing fastness values are good. Silk fabric samples' have better test values. Silk fabric sample dyed with waste of *Origanum onites* have 5 wet rubbing value means excellent and good for washing fastness. With the friction fastness test results, it has been determined that both fabric types have very high fastness values. As can be understood from these test results, the fastness values of animal based fabrics give noticeably better results. For cellulose-based fabrics, it has been revealed that improvements should be made in the printing and finishing processes.

Result

The aim of the study was to transfer natural dyes obtained from essential oil extracted plant pulps to a surface by screen printing technique and to provide sufficient fastness values, and the study was successful in this respect.

The study, the first 3 stages of which were carried out within the framework of this article, can be briefly evaluated in terms of purpose and procedure as follows:

- Obtaining natural dyes from essential oil extracted plant pulps
- Utilization of the obtained natural dyes in the screen printing process
- Bringing the fastness values of natural dyes transferred to a surface by screen printing technique to a sufficient level
- To use natural dyes in screen printing on an industrial scale
- In this way, to make a positive contribution to sustainability by offering an alternative to the disadvantages of traditional screen printing techniques with natural dyes.

In the preliminary study of the research conducted within the scope of the proficiency in art thesis project, many different dyestuff sources and auxiliary substances were tried and the best results obtained were included in this study. Especially at the point of ensuring the fastness of the dye after printing, quite a lot of experiments were made. It has been seen that it is possible to work with every dyestuff source used in natural dyeing only with the use of appropriate auxiliaries and fixing process. Within the scope of the study, it was concluded that natural dyes can be used in screen printing and fastness values can be increased with the necessary thickening and adhesion enhancing auxiliaries. Guar gum was used as thickener and gum arabic was used as adhesion enhancer. In order to ensure fixation with completely natural methods, the printed fabrics were first dried for 24 hours, ironed intermittently during this period and finally soaked in water with sea salt added for 2 hours. In addition, it should not be forgotten that fabric preparation processes are also very important in increasing the fastness values. At this point, pre-mordanting was preferred within the scope of the study and alum was used as mordant.

In pre-experimental stage, besides thyme(*Origanum onites*) and sage(*Salvia tomentosa*), natural dyes obtained from various plants such as bay leaf (*Daphne sericea* Vahl), nutgalls (*Quercus infectoria*), walnut (*Juglans regia* L.) were used. In the beginning, printings were tried on different types of cellulose and protein based fabrics, then the applications were continued with cotton and silk fabrics. Guar gum was used as a thickener (viscosity enhancer) in order to make the dyestuffs suitable for screen printing. In addition, arabic gum, which was found to give positive results in terms of adhesion to the dye, was also added.

Alum, vinegar and soy milk were used for mordanting the fabric and the best results were obtained with alum, which is a more advantageous mordant in terms of cost.

Screenprinting was applied on dry and moistured fabrics and it was observed that moist applications produced more vivid and bright colors.

Apart from all these, another reason for the originality of the study is the development of 3 new emulsion-free printing techniques independent from the emulsion printing technique applied as standard in screen printing technique. It is very difficult for natural dyes and prints made with traditional methods to find a presence in the sector that acts with the logic of fast production. With this study, which proves that the use of natural dyes in screen printing technique is possible and provides sufficient fastness, it is hoped that the industrial use of natural dyes with screen printing technique will be accepted and widespread in the future.

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Image References

Görsel 1.

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Yapılandırılmış Özet

18'inci yüzyılın ikinci yarısında Sanayi Devrimi ile kapitalist ekonominin yaygınlaşması, insan, doğa ve evren anlayışını değiştiren yeni bir dünya düzenini başlatmıştır. Ne yazık ki bu yeni düzen aynı zamanda çevremiz için artan atıklar, tükenen doğal kaynaklar, türlerin yok olması, ozon tabakasının delinmesi, çevre kirliliği, iklim değişikliği ve nihayetinde ekosistemlere verilen zarar gibi çeşitli tehditleri de beraberinde getirmiştir. Sanayi Devrimi'nin ilk uygulama alanı olan tekstil sektörü, bu sorunların başlıca sorumlusu olarak görülmektedir. Zaman içinde, doğal kaynakların ve kimyasalların aşırı kullanımının zararlı etkileri tüketiciler ve uluslararası kuruluşlar tarafından gün ışığına çıkarılmıştır. Çevrecilik, ekoloji ve sürdürülebilirlik yaklaşımları daha yaygın hale gelmiş ve dünyanın çeşitli yerlerinde tekstil endüstrisini de kapsayacak şekilde genişlemiştir. Literatür, tekstil sektöründe sürdürülebilirliği "tekstil ekolojisi, ekolojik sürdürülebilirlik, sürdürülebilir tasarım, sürdürülebilir moda, yavaş moda, yavaş tasarım ve yeşil üretim" gibi çeşitli kavramlarla ele almaktadır. Ancak sektörün hammadde, iplik, dokuma, örme, ön işlem, boya/terbiye, baskı, hazır giyim ve moda gibi alanlardaki üretim uygulamaları, ekolojik sürdürülebilirlik yaklaşımıyla temelden çelişmektedir.

Türkiye'de her yıl yaklaşık olarak 1.155.000 ton tekstil atığının ortaya çıktığı görülmektedir. Eğer Türkiye'de çöpe giden polyester ve pamuk ürünleri geri kazanılmış olsa, yılda yaklaşık 13,1 milyar kwh enerji pamuktan, 14 milyar kwh enerji polyesterden kazanılabilecektir (Altun, 2014, s. 11- 15). Son verilere göre, sektörden kaynaklanan etkiler arasında yılda 92 milyon tondan fazla atık ve tüketilen 79 trilyon litre su yer alıyor. Bu çevresel etkilere dayanarak, üretimin yavaşlaması ve tedarik zinciri boyunca sürdürülebilir uygulamaların başlatılması ve ayrıca tüketici davranışında bir değişiklik meydana gelmesi gerekmektedir (Ninimaki vd., 2020, s. 189).

Zaman içinde, kamuoyu kimyasalların ve sentetik boyaların olumsuz etkilerinin giderek daha fazla farkına varmış, bu da doğal boyaların yeniden canlanması için bir itici güç olmuştur. Buna rağmen, doğal boyaların sektördeki endüstriyel uygulamaları karmaşıklığını korumaktadır. Doğal elyaf, kumaş ve boyaların kullanımı, insan ekolojisinin genel sürdürülebilirliği için önemlidir. Sentetiklerin aksine doğal hammaddelerin kullanımı, ekolojik sürdürülebilirliğin temel bir ilkesidir. Ancak bu hammaddelerin sektörde doğal halleriyle kullanılması sürdürülebilirlik felsefesiyle çelişmekte ve doğanın sınırlı kaynaklarının tükenmesine yol açarak ciddi bir paradoks oluşturmaktadır. Mevcut konjonktürde bu sorunun çözümü için, uçucu yağ elde edilen bitki posalarının yeniden kullanımı olduğu düşünülmektedir.

Boyama/ renklendirme işlemi sektörün en önemli uygulama süreçlerindedir. Renk, geleneksel veya akıllı tekstiller için doğal veya sentetik boyamaddelerin kullanıldığı tekstil üretiminde ve uygulamasında önemli bir faktördür (Meram, Abdelrahman vd., 2020, s. 264). Doğal boyaların tekstil boyama amaçlı kullanımı, 1856 yılında sentetik boyaların keşfedilmesinden sonra büyük ölçüde azaldı (Arora, Agarwal, ve Gupta 2017, s. 35- 36). 1856'da Henry Perkin tarafından yapılan keşif ve sentetik boyaların ticarileştirilmesinden sonra doğal boyaların tüketimi önemli ölçüde azalmıştır. Ancak son dönemlerde insanların çevre bilincinin artması tekstil sektöründe doğal boyaların kullanımını daha da artırmıştır. Sentetik boyaların toksik ve alerjik etkileri, insanları doğal boyalara yönlendirmektedir. Doğa ve insan sağlığının korunması konusunda temkinli olan ülkeler tarafından tekstil ve hazır giyimde uygulanan titiz çevre standartları, tekstil malzemelerinin renklendirilmesinde doğal boyalara olan ilgiyi canlandırmaktadır (Gupta, 2019). Günümüzde üretimi ve uygulaması ciddi sağlık tehlikelerine sebep olan ve doğanın ekosistemine zarar veren, yılda yaklaşık 10.000.000 ton sentetik boya kullanılmaktadır (Iqbal ve Ansari, 2014, s. 683). Tekstil endüstrisi sentetik boyaların kullanımı nedeniyle çevreyi kirlletmektedir (Guha, 2019, s. 40). Sentetik boyaların üretimi enerji yoğunudur. Bu boyaların birçoğunun, özellikle azo bazlı olanların kanserojen olduğu bilinmektedir (Prabhu ve Aniket, 2012). Şu anda, çevre dostu olmayan tüm sentetik bileşikler, tekstil malzemelerinin boyanması için kullanılmaktadır. Biyolojik olarak parçalanamazlar, kanserojendirler ve su kirliliğinin yanı sıra atık bertarafı sorunları yaratırlar. Doğal boyalar bu sorunlara makul bir çözüm sunar (Arora, Agarwal ve Gupta, 2017, s. 35). Doğal boyalar; bitkiler, hayvanlar, mineraller ve mikroorganizma gibi doğal kaynaklardan elde edilir. Sentetik boyaların toksisitesi, kanserojenliği ve alerjik reaksiyonları doğal boyalara olan ilgiyi artırmıştır (Karuna, Pankaj ve Singh, 2019, s. 87). Doğal boyaların insan cildi üzerinde tahriş edici bir etkisi yoktur. Doğa, boyama işlemlerinde kullanmamız için bize birçok bitki sunmuştur.

Tüm bu bahsedilenlerden yola çıkarak; ilgili çalışmanın problem cümlesi, "Sürdürülebilirlik Bağlamında Uçucu Yağı Alınmış Bitki Posalarının Tekstil Baskıda Kullanılabilirliği" olan çalışmanın temel amacı, doğal boyaların endüstriyel olarak tekstil baskı sektöründe kullanılabilirliğini ortaya koymaktır. Yapılan ön değerlendirme sürecinde baskı yöntemi olarak serigrafi baskının doğal boyaların endüstriyel entegrasyonu için önemli avantajlarının olduğu görülmüştür. Buradan hareketle, deneysel araştırma yöntemi ile gerçekleştirilen uygulamalar ve analizler sonucunda, uçucu yağ alınmış bitki posalarından elde edilen doğal boyanın serigrafi tekniği ile tekstil yüzeyine aktarılması ve yeterli haslığın sağlanması ile doğal boyaların endüstriyel boyutta kullanımının mümkün olacağı ortaya çıkmıştır. Bu çalışmada serigrafi baskının geleneksel kumaş baskı tekniklerine bir alternatif olarak sunulmasının yanı sıra bitki posalarından elde edilen doğal boyaların kullanımı ile sürdürülebilirliğe olumlu katkılar sağlanması da amaçlanmıştır. Bu da çalışmanın önemini artırmaktadır. Sonuç olarak, uçucu yağ alınmış bitki posalarından elde edilen doğal boyaların serigrafi tekniği ile kumaşa aktarılabilirliği, ön mordanlama işleminin ve tuzlu suda sabitleme işleminin yıkama ve sürtünme haslık değerlerini arttırdığı görülmüştür. Tüm bunların dışında serigrafi baskı tekniğinde standart olarak uygulanan emülsiyon baskı tekniğinden bağımsız üç yeni emülsiyonsuz baskı tekniği geliştirilmiştir.