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From Craft to Industry

ABSTRACT

In this paper, we discuss the potential of using traditional knowledge of natural dyes for more sustainable development processes in textile design. Our aim is to help foster a green transition through responsible consumption and production. We investigate the potential for implementing natural dye processes from craft to industrial processes to replace synthetic dyes. We adopt a systematic approach to dyeing and printing with food waste, including walnut shells, avocado skins and onion skins, specifically exploring colourfastness. We have observed that craft methods tend to be 'forgotten' due to the zeal for industrialization and the standardizing of products to ensure quality requirements. From students and business partners, we experience requests for natural dyes; however, we are challenged to document colourfastness. Knowledge and documentation are of high importance when we intend to convince industry to learn from traditional crafts. Through a systematic investigation testing traditional recipes and variations in dyed textiles, we experience how textiles perform. Through iterations based on the

results, we continue with further experiments and simultaneously discuss whether both the consumer and the industry have to look at quality requirements from a conventional perspective. We argue that current expectations regarding colours and standards must change. Facing radical changes to the way we live, produce and use products, it is important to critically examine our approach to conventional industrial production. In our research, we built knowledge generation on cultural heritage and traditional craft. We argue how this becomes a societal asset influencing users' behaviour and creates awareness towards sustainable changes in the design and use of textiles.

Keywords:

natural dyes, responsible production, cultural heritage, traditional crafts, contemporary design.

INTRODUCTION AND BACKGROUND

With the increasing focus on sustainable transition in general and the fashion design context specifically, we are experiencing increased demand for alternative and more responsible ways of producing textiles. Right now, the textile industry is facing nothing less than a paradigm shift, as the EU, on March 30, 2022, launched a new textile strategy under the name 'EU Strategy for Sustainable and Circular Textiles' (Directorate-General for Environment, 2022). The strategy expectedly affects all stages of the textile industry, with demands for a circular economy, closed loops, increased producer responsibility and a wide range of stricter requirements for textile production. Companies are becoming more aware that they need to align their strategies, production and products to comply with the EU strategy. At VIA University College, design and business students work in an interdisciplinary and project-oriented manner in close collaborations with companies from the fashion and lifestyle industry. Through these collaborations, we are confronted with the many issues the industry faces that are related to responsible production and equally significant around waste management in relation to circular production, aka closed-loop systems.

One of the issues concerns circularity related to the use of conventional dyes in the dyeing and printing processes, which is the focus of this paper. Conventional dyes and dyeing processes are generally problematic, both in the front end and back end of products' lifetimes. At the front end, synthetic dyes have a noticeable impact on the environment (Hudd, 2022). In the back end, dyes can be problematic in relation to recycling, often causing clothes with dyes and prints to be more difficult to transfer to closed-loop systems with the current recycling technologies, as a result of which they are forced to enter into downcycling. Our aim is to contribute to fostering the green transition through responsible consumption and production. Consequently, we explore how we can be more environmentally responsible with textile dyeing in an industrial context. This paper demonstrates elements of our research on how we can apply knowledge from the traditional craft of 'dyeing'. The point of departure has been to investigate the knowledge contained in handed-down recipes and their methods and techniques, which constituted the field of dyeing in former eras, and to systematically test the functionality, usability and authenticity in our test laboratory against today's standards.

Synthetic versus Natural Dyes

For centuries, dyers have extracted colour pigment from various sources, including plants and insects, and have used these natural colour extracts to dye clothes. However, the invention and spread of synthetic dyes has resulted in natural dyes today being used almost exclusively by craftsmen and private individuals. Throughout the 20th century and until now, we have mostly focused on the beneficial properties and advantages of synthetic dyes. Different synthetic dyes have different properties and are used for different fibre types. What they have in common is that they are homogenous, which means you can expect the colour to be the same every time you dye, and the authenticity is generally high in lab tests. The downsides are the environmental consequences associated with the use of these dyes, partly in the production of the colours and in their use in expanding industrial textile production and partly in the use and disposal phase. In recent years, many efforts have been made to reduce the environmentally harmful substances in colours, meaning that today more synthetic dyes are eco

passport-certified (oeko-tex.com, 2023) and less harmful to the environment than they were in the past. However, they are still synthetic and not bio-based, meaning that they possibly still have a negative environmental impact. This is generally acknowledged, but we have not been able to verify it for this paper. In the current circumstances, with the aforementioned EU strategy in mind, forcing the industry to think and act circularly, there may be reasons to assess natural dyes and reintroduce them into the agenda and the industry. There is growing interest in natural dyes in the industry, where companies including Archroma (Archroma, 2023) now offer natural dyes as part of their colour selection and the company Eyand (Eyand, 2021) works exclusively with natural dyes.

We experience that our students, business partners from the industry and ourselves as teachers lack documentation for the colour fastness of textiles dyed with natural dyes. We have therefore set out to obtain data that can document the colours' fastness, in order to provide our students and the industry with data they can use as a starting point for their investigations, projects and considerations.

Methodology

From an ethical perspective, we have chosen to work exclusively with waste products from food production as a colourant. With the increasing global population, there is no point in using valuable agricultural land for plant material with the sole purpose of extracting dye. Agricultural land must be used for food. In connection with our project, we entered a collaboration with the canteen at VIA University College and have used food waste from their kitchen supplied with our own collected food waste. We have experimented with a variety of different types of food waste, including yellow and red onion skin, avocado skin and seeds, pomegranate, celery tops, walnut shells, coffee grounds and passionfruit shell. The point of departure for our research consisted of desk research into previously used recipes and techniques related to natural dyes. The literature we have used includes 'BOTANICAL INKS Plant-to-Print Dyes, Techniques and Projects' (Behan, 2018) and 'The Art and Science of Natural Dyes, Principles, Experiments, and Results' (Boutrup & Ellis, 2019). The reason we start from existing recipes is that we want to apply knowledge from earlier times and compare the results with today's industrial standards. Learning and gaining knowledge from traditional crafts and recipes ensures that they represent an alternative to the synthetic dyes so diffused in the industry today. In this paper, we do not describe the dyeing processes, including tannins, mordant, dyes and modifiers, but focus on the methodology and test results. We have reduced all tannin, mordant and dyeing processes to one hour instead of up to the 12 hours generally recommended by traditional recipes. We have chosen to test and work with this time span, as the original timeframe with long processes is considered unrealistic in an industrial context.

We have divided our research into three phases in an explorative process in which each phase establishes the purpose of the next phase as questions and hypotheses emerge. We elaborate on the three phases in the overview below. Phases 1 and 2 focus on testing how dyeing with food waste can meet current industrial standards. Phase 3 focuses on a future scenario with alternative options. What if we have to accept greater colour variations to accommodate the green transition? In phase 3, there is a focus on changing aesthetics, and we decided not to test authenticity, as the scenario changes over time through several layers of over-dyeing in the user phase.

Research phase 1 – testing existing recipes

Purpose: To develop data that can form the basis for further investigations

Question: How can textiles dyed with colourants from food waste comply with current industrial standards?

Methodology: Test existing colour recipes for silk, wool and cotton

Testing colour fastness in the laboratory according to DS/EN ISO105-X16:2016* (colour fastness to rubbing) and DS/EN ISO 105 –C06: 2010** (colour fastness to washing)

* ISO 105-X16:2016 specifies a method for determining the resistance of the colour of textiles to rubbing off and staining other materials (iso.org.2021)

** ISO 105-C06:2010 specifies methods intended for determining the resistance of the colour of textiles of all kinds and in all forms to domestic or commercial laundering procedures used for normal household articles using a reference detergent. (iso.org.2020)

Research phase 2 – dyeing with onion skin

Purpose: To assess whether the industry's requirements for reproducibility can be met.

Question: How can we be sure of getting the same colour result when, for example, onion skin originates from different places?

Methodology: Group A: Five dyebaths with onion skin from different suppliers/origins. Group B: Five dyebaths with onion skin from different suppliers/origins collected over a long period. The skins were mixed and chopped into granules prior to dyeing. This was followed by a test in the laboratory to document colour tolerance Delta E CMC (Mouw, 2018). Delta E CMC tolerance was set to 1. Test equipment: X-rite Ci4200^{uv} Compact Benchtop Spectrophotometer. This standard measurement method can identify variances in colour and gloss to ensure accurate colour reading. We also use it to verify a visual inspection of the colour.

Research phase 3 – testing direct and mordant printing

Purpose: To investigate changes in the aesthetic expression of textiles by overprinting several times based on the question of how we can change the perception of quality requirements, both as consumers and designers, producers and suppliers.

Question: How can we screen-print with colourants from food waste? How can we work in layers when using these for direct and mordant printing?

Methodology: A: Test existing direct printing and mordant printing recipes without working in layers. B: Test existing recipes where printing is done in several layers and overdyed. Authenticity has not been tested here, but the work has been based on the keywords: changing aesthetics and multiplying layers.

RESULTS AND ANALYSIS

Research phase 1 – Testing colour fastness

Because we intend to transfer knowledge from craft to industry, it was important for us to test, analyse and gain knowledge about the exact performances of the natural dyed textiles compared with Danish and international colour standards. We wanted to test natural dyed silk, wool and cotton fabric in our laboratory to get data to compare to established standards, such as DA/EN ISO standards. We dyed fabric with avocado skin and seed, red onion skin, eucalyptus, celery top and walnut shell. We grade the results from 1 to 5, with 5 being the best.

We have achieved good results in terms of colour fastness to rubbing and colour fastness to washing on wool, silk and cotton. In relation to colour change, the result for wool and silk is also fine, but the colour change on the cotton samples in the wash is very large and the samples do not pass the test. Dyeing with food waste on protein fibres could immediately work well for dyeing textiles, but if cotton is to have a chance on a commercial level, we believe that work must be done to achieve better fastness in colour change when washing cellulose-based fabrics. Alternatively, as we argue in this paper, we can try to investigate new versions of standards and challenge these as well as our

perception of aesthetics related to colour perfection or imperfection. For future investigation, we must test different tannins and mordants to improve colour fastness on cellulose-based fabrics. According to Boutrup and Ellis (2019, p. 51), *'The quality, quantity, and application of the mordant will affect the final colour of the dye. The mordant is essential for the lightfastness and washfastness of a mordant dye.'*

Methodology	Result; Wool & Silk	Result; Cotton
Colour fastness to rubbing DS/EN ISO 105-X16: 2016	In general, wool and silk passed the rubbing test positively. All tests were passed in the dry state, but in the wet state, the test in wool with avocado failed with a grade of 2–3. Otherwise, all notes were 4–5 or 5.	Cotton succeeded also in the rubbing test very well in dry fabric. The wet rubbing test with red onion failed with a grade of 1–2 out of 5, with 5 being the best.
Colour fastness to washing* DS/EN ISO 105-C06:2010 *Colour fastness to washing includes colour staining and colour change	<i>Colour Staining:</i> All tests were passed with fine results of grades 4–5 in colour staining on acetate, bleached cotton, polyamide, polyester, polyacrylic and wool. <i>Colour change:</i> Three out of 11 samples had a large colour change in washing with notes 2, 3–4 and 3–4 and thus failed. All 3 were on wool.	<i>Colour Staining:</i> All tests were passed with fine results of grades 4–5 in colour staining on acetate, bleached cotton, polyamide, polyester, polyacrylic and wool. <i>Colour change:</i> Four out of 4 samples had a large colour change in washing with notes 1–2 and thus failed.

FIGURE 1. Results of colour fastness on wool, silk and cotton fabric.

Research phase 2 – testing colour repeatability

In phase two, we asked: How can we ensure to get the same colour result several times when, for example, onion skin comes from different places? In this phase, red onions were chosen due to their easy availability. During our experimental process, we experienced a variation in colour shades and realized through our test logs that the origin of food waste had an impact on this. The pictures below (Figures 2 and 3) illustrate the results and variations in cotton and wool fabrics, respectively.



FIGURE 2. The result of dyeing group A with onion skin from different suppliers/origins. Cotton is on top and wool is below.

The first test, group A, as demonstrated in Figure 2, was carried out with liquid extract from onion skins, which was not granulated and mixed. The samples showed such a large variation in colour that we were able to conclude that the colours were not the same.



FIGURE 3. The result from group B with onion skin from different suppliers/origins collected over a long period. The skins were mixed and chopped into granules and converted into liquid form prior to dyeing. Cotton is on top and wool is below.

The second test, group B, as demonstrated in Figure 3, seemed very identical and we used the test equipment X-rite Ci4200^{uv} Compact Benchtop Spectrophotometer to verify the colour results.

Figure 4 shows colour tolerance. Each dot in the figure represents one tested sample. A green dot means passed and a red dot means failed in colour tolerance.

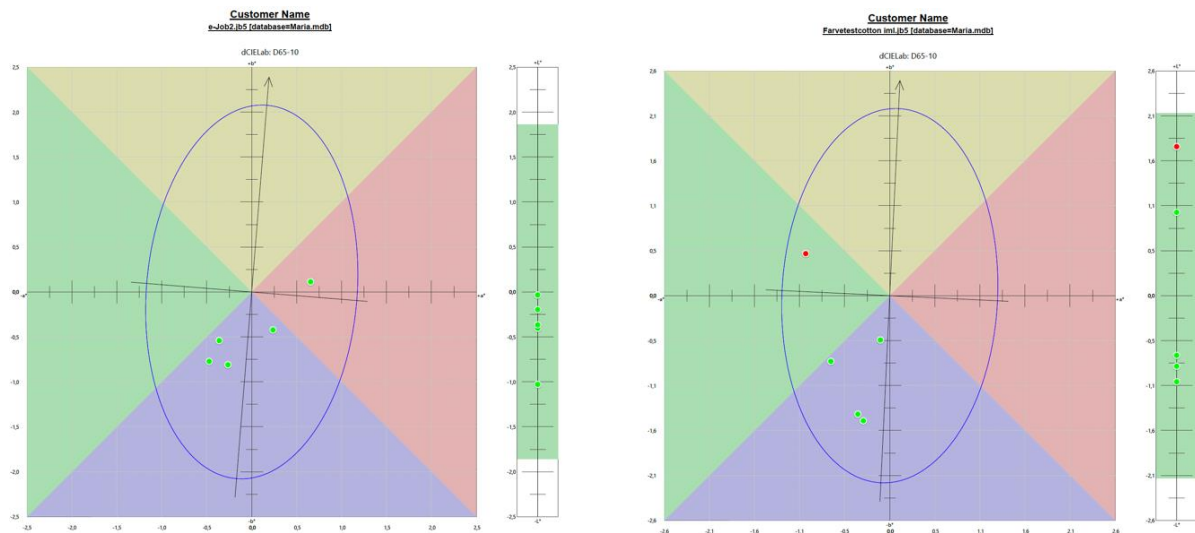


FIGURE 4. Results of colour tolerance test Delta E CMC. To the left is test for wool and to the right is cotton. One out of 10 samples failed.

The experiments document that collecting onion skin to get a relatively huge batch mixing and granulating, we are able to get the same colour several times. We acknowledge that in industrial production, using onion granules could be a solution to obtain results that comply with the industry's current paradigm. From another perspective, we could ask: What if we could change the paradigm? Will it be possible to change aesthetics and look at clothes in a different way? What if we could add new value to clothing by changing aesthetics? Could the clothes have a longer life span if the user could be a co-creator by refreshing the clothes through re-dyeing, printing or painting? These speculative thoughts led us to the third research phase.

Research phase 3 – mordant and direct printing

Using recipes about direct printing and mordant printing (Boutrup & Ellis, 2019), we explored the techniques with different versions of print designs. The point of departure was a classic print of stripes with mordant and direct printing, as seen in Figure 5. The print design consists of a traditional understanding of 'perfect' with even stripes. The next step was experimenting with print designs where the 'imperfect' and uneven was the premise. Figure 6 shows these imperfect direct-printed stripes, and the print appears a little broken and worn. Our approach was to explore whether a print, which was deliberately designed as imperfect from the starting point, could contribute to changing users' mindset about the perfect state of clothes. Moreover, we wished to explore whether deliberately designed imperfections could alter users' expectations of the uniformity of the expression of clothes and thus contribute to an acceptance of changing aesthetics and a longer lifespan of clothes.



FIGURE 5. 'Perfect' stripes



FIGURE 6. 'Imperfect' stripes

The experiments with perfect and imperfect stripes led us to continue exploring printing with multiple layers. This phase of the research was intended to test the possibilities of preparing prints that users could re-dye themselves and create new and changed aesthetics. We used the prints illustrated below to mimic how printed fabric could appear through user interaction. Figure 7 illustrates mordant printing using both red and yellow onion skin, and Figure 8 illustrates mordant printing using avocado skin and yellow onion skin.



FIGURE 7. Mordant printing with red and yellow onion skin



FIGURE 8 Mordant printing with avocado and yellow onion skin

Applicable to the samples in both Figures 7 and 8 is that the first piece of textile on the left is dyed once and forms a starting point for comparison. The next four samples in both figures have all been dyed

twice: first with the same colourant and then with a new colourant. The last two samples in the series have both received additional mordants and have also been dyed in the same colourant and the new colourant. The experiments demonstrate that it is possible to print and overdye several times, thus changing the aesthetics of the fabric. We evaluate this initiative to contribute to the reduction of downcycling; however, we have not yet tested it with users.

CONCLUSION/REFLECTION

Through our investigation, we have exemplified how we can build our knowledge generation on cultural heritage and traditional crafts. Our investigation began due to a desire to work with more responsible production. Instead of developing new technology or dyestuffs, we looked into the possibilities of connecting the past with the future by systematically investigating known dye recipes and letting the exploration lead us to new knowledge and experiences. We expected only to be able to develop data for documentation of colour fastness, but through dialogue in our team and the dialogue of the process, we discovered new ways to look at and perceive aesthetics. We cannot know if the user or the industry will embrace our way of working with changing aesthetics, but we do know that the system must be changed in the basic perception of norms and values and that we can thereby become co-creators of a narrative around a new way of looking at and attaching emotionally to clothes in the use phase. We are now in a phase in which we want to test how natural dyes and multiple layers will perform in practice when they reach the user. If the users become a co-creator of the clothes they wear by taking food waste and turning it into dye, the waste becomes upcycled and over time the clothes will change aesthetics without losing value. In that way, we argue how traditional knowledge and craft can become a societal asset influencing users' behaviour and creating awareness towards sustainable changes in the design and use of textiles.

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