https://doi.org/10.24867/GRID-2024-p80 Preliminary report

IMPROVEMENT OF TRADITIONAL PAPERS SURFACE AND AS USE FINE ART PAPER

Öznur Özden [1], Yeter Beriş [2]
[1] Istanbul University-Cerrahpasa, Forest Faculty, Forest Product Chemistry and Technology, Istanbul, Turkey
[2] Istanbul Gedik University, Faculty of Architecture and Design, Department of Digital Game Design, Istanbul, Turkey

Abstract: *The objective of this study is to promote a more dynamic utilization of traditionally produced papers for artistic purposes. Specifically, the aim is to enhance the suitability of papers made through traditional methods using bast fibres from hemp, flax and linden plants for drawing and painting. To achieve this goal, a polysaccharide-based biopolymer material was employed during production. This biopolymer material was utilized in two ways: during the papermaking process and subsequently as a surface coating, where it was combined with starch. The visual quality and printability of the resulting papers, both produced and coated, were assessed.*
In our research, seaweed was utilized as a biopolymer to contribute to sustainability efforts. The inclusion of seaweed extract improved both the surface and barrier properties of the papers. By integrating bi-based seaweed into this study, we aim to introduce a new dimension to traditionally produced papers while promoting the principles of the circular economy.
This preliminary study aims to lay the groundwork for future research by providing insights that enhance the quality of artistic papers in both traditional and industrial paper production contexts.

Key words: Traditional paper, coating, printing, alga, seaweed, biopolymer

1. INTRODUCTION

Since its invention, paper has held a significant place in our lives, and although it has been continuously developed over time, its basic production method has remained the same. Paper was first produced in China and brought to Europe in the 11th and 12th centuries. After observing the paper mills in Italy, a German entrepreneur, Ulman Stromer, established the first paper mill north of the Alps, in Nuremberg. The printing revolution, initiated by Johann Gutenberg's invention of the printing press, was able to progress due to the prior establishment of paper mills such as Stromer's (Bloom, 2001).
Etymologically, the word 'paper' is derived from the Ancient Greek word papyrus, which was used for the Cyperus papyrus plant. The papyrus refers to a thick, paper-like material produced from the pith of the Cyperus papyrus plant, commonly used for writing in ancient Egypt. Before the industrialization of paper production in China, the most common source of fibre was recycled fibres obtained from used textiles, known as rags. These rags were made from hemp (Cannabis sativa), flax, and cotton. In Rajasthan, India, rare Islamic papers were made from hemp or grass stalks, dyed with plant-based colours, and polished by rubbing the sheets with a smooth stone (Khadi papers). The invention of paper from softened plant fibres is mostly attributed to the Chinese eunuch Ts'ai Lun (105 AD). The exact date of the first production of paper in India remains unclear; however, some sources believe that paper was independently invented in India during the Buddhist period, around 250 BCE (Mukherjee & Keshri, 2018).
The annual production of petroleum-based packaging and other products continues to increase, depending on usage. In 2018, it reached 360 million tons, with 10% to 20% of this increase, which ranges between 22% and 43% annually, ending up in landfills and oceans. As a result, the consumption and consequently the production of paper, which serves as an eco-friendly alternative to plastic due to its recyclability, is steadily rising. In response to this, researchers have increasingly focused on developing fully bio-based polymer films in recent years. Edible and biodegradable films, such as those made from starch and ulvan, have also seen increased attention in innovative studies due to their sustainable properties. In this context, studies are being conducted to develop packaging using ulvan and starch as alternatives to plastic packaging.

In this study, rather than using ulvan for packaging production, it was preferred for enhancing the properties of paper through surface coating. In 1996, a bachelor's thesis on paper production from seaweed was conducted in the Forest Products Chemistry and Technology Laboratory at Istanbul University-Cerrahpasa Faculty of Forestry. Since the produced paper exhibited low-quality properties, it was observed that seaweed alone was not suitable for paper production. As a result, it was decided to mix seaweed with wood fibres for production. Taking this drawback into account, and drawing on the idea that using seaweed on the surface of paper, rather than in its production, would be more interesting in light of recent innovative studies, this preliminary study was initiated. For this study, film coating experiments were carried out to improve the printability of handmade papers used in “Fine Art” printing by coating their surfaces with ulvan obtained from the extraction of green algae Ulva Lactuca sp.
The impact of paper, as a writing material, on people is too significant to be overlooked. Paper's primary function is to carry and disseminate information, but it is also widely used as packaging and as an artistic material. Since its invention, the paper has been continuously developed from a technical perspective. The journey of paper, which began 2,000 years ago with Ts’ai Lun in China, also marked the beginning of communication and artistic developments. Over the years, the paper has continued to serve as a medium for art, extending beyond writing to include everything from calligraphy to modern multi-colour prints. From this perspective, handmade papers are considered a unique art material, particularly because the natural beauty of their fibres contributes to artistic expression. Even the imperfections in these papers are seen as part of their charm, adding depth to the artwork. In this context, handmade papers can be regarded as canvases designed specifically for artists, who use them to create artwork with the help of paints and printing techniques.
In recent years, advancements in digital printing solutions have positively changed artists' perspectives on fine art edition productions. Technological improvements in material availability and print quality have made fine art printing more feasible. However, fine art printing still requires special attention to every aspect, from the substrate materials and printing inks to the printing and drying processes. Fine art printing involves reproducing paintings, photographs, drawings, and more using a digital printer and high-quality papers made from plants such as flax and hemp. The goal of this printing process is to produce long-lasting prints that remain faithful to the original work in terms of colour and detail. For this reason, both the ink and paper are crucial. The surface coatings of the papers used for artistic printing are expected to preserve colours and extend the lifespan of the artwork (Carnie, 2024).
In this study, handmade papers were produced as artistic papers using flax, hemp, and linden bast fibres. To improve the printability of the produced papers, a surface sizing process was applied. As an innovative approach, rather than traditional sizing methods, the surfaces were sized with seaweed extract. Seaweed, a type of microalgae, is categorized as green, brown, or red. Green seaweeds, as shown in Figure 1, are diverse, and our study material, Ulva Lactuca spp. (Figure 3a and b), is also an edible seaweed.

Figure 1: Varieties of Green Seaweeds

Algae are diverse in terms of their habitats and characteristics, ranging from single-celled forms like Chlorella sp. and diatoms to large, multicellular forms such as brown algae. Algae, which play a promising role in carbon sequestration, contribute to 50% of global photosynthesis. Algae used as raw materials in papermaking are seen as an innovative and alternative resource in addressing global environmental issues such as deforestation and global warming. Algae contain hemicellulose and cellulose but lack lignin, which is a desirable trait. When wood is used as a raw material in pulp production, lignin must first be removed from the material. However, when algae are used, this process is unnecessary. Nonetheless, algae alone are not suitable for producing high-quality paper; they need to be reinforced with appropriate annual plant or wood fibres. Green seaweeds, which are an important part of coastal ecosystems, are rich sources of polysaccharides and amino acids. Studies have shown that the main components of Ulva seaweeds are cellulose and hemicellulose, with little to no lignin content.

2. METHODS

Samples of Ulva Lactuca spp. were collected from the shores of Sinop and Sinop-Gerze, located along the Black Sea coast of Turkey (Figure 2), during June and July 2024. The algae samples naturally grow on the rocky shores of the coastline. The collected seaweed samples (Figure 3a and b) were first washed with tap water and then with distilled water to remove sand and other debris. They were subsequently dried in an oven at 40°C. The dried seaweed samples were ground at the Oozden & KBA workshop. Until they were used, the samples were stored in a dry container at room temperature.

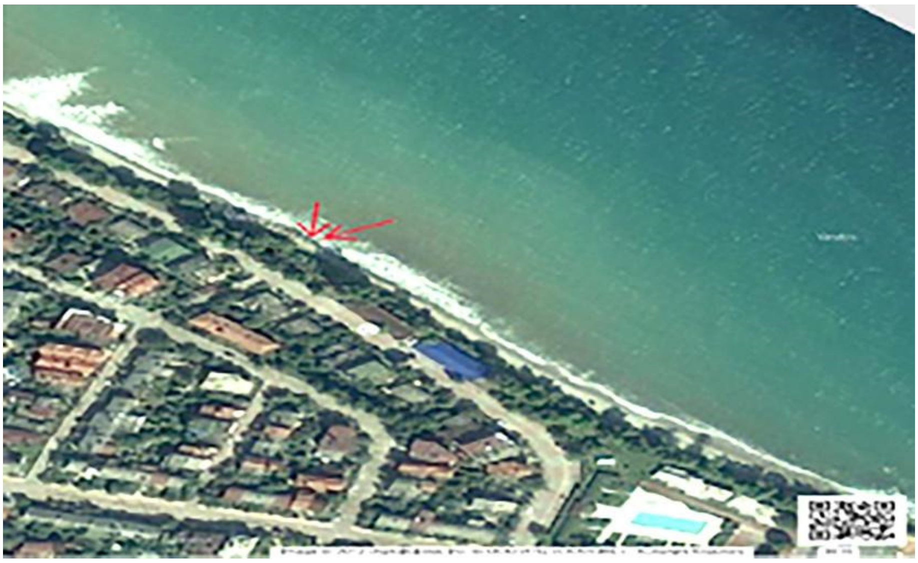


Figure 2: Ulva Lactuca Sample Area Sinop-Gerze Coast (from Google Map)

Figure 3a and b: Green Algea-Ulva Lactuca Spp. from Blacksea-Sinop and Gerze

For this preliminary study, traditional papers were produced using pulps made from flax, hemp, linden, and cotton bast fibres through traditional methods at the Oozden & KBA (Öznur Özden & Paper, Dye Workshop) studio (Figure 4). The papers were produced in A4 size, with an average weight of approximately 80g/m². No additives were used during the production of these papers.

Figure 4: Hemp pulp and hemp, linen, cotton and linden papers

From the ground samples of Ulva Lactuca spp. (Figure 5a and b), Ulvan was extracted to form Ulva films (Figure 6). Ulvan is a sulfated polysaccharide found in the cell walls of Ulva Lactuca spp. and is soluble in water. The Ulvan content in Ulva varies between 8% and 29% depending on the species (Wahlström, 2020). For this purpose, Ulvan, a polysaccharide, was dissolved in hot water extract, and 0.1% boric acid was added to the solution as a cross-linking agent. The suspension was plasticized by the addition of 2% glycerol. To achieve a homogeneous suspension, it was mixed with a magnetic stirrer at 50°C for 25 minutes and then stirred at room temperature for an additional hour (Sulastri et al., 2021). The prepared suspension was applied to the surfaces of the handmade papers both transversely and longitudinally using a brush. Subsequently, fine art prints were made on the coated paper samples. Ulvan hydrogel films were prepared by ionic cross-linking with boric acid and the addition of glycerol as a plasticizer.

Figure 5a and b: Dried and Ground Ulva Lactuca

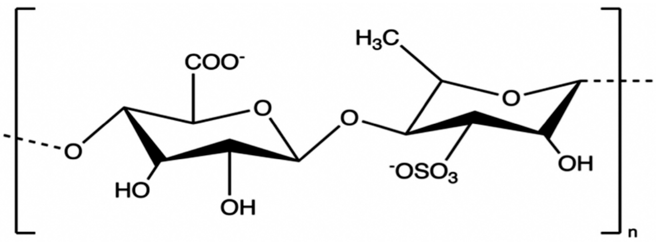


Figure 6: Chemical structure of ulvan (Wahlström, 2020)

The papers to be used for fine art printing were produced at the Oozden & KBA workshop. Handmade papers were created using pulps obtained from cooked flax, hemp, and linden bast fibres. The surfaces of the produced papers were coated with Ulvan hydrogel films extracted from seaweed, utilizing the method applied in Özden's natural tannin coating study (Özden, 2018). Test prints were made at the Fine Art Sanatsal Baskı Ltd. Studio using a Canon Pro 4100 model Ink Jet printer with 12 colours. In the Canon inkjet printing setup, an ICC (International Colour Consortium) profile was created using the i1-x-rite colour production calibration device, and the test print results were evaluated.

3. RESULTS

The International Colour Consortium was established in 1993 by eight industry suppliers with the aim of creating, supporting, and promoting the standardization and development of an open, vendor-independent, cross-platform colour management system architecture and components. As a result of this collaboration, the ICC profile specification was developed. The purpose of the International Colour Consortium® profile format is to provide a cross-platform device profile format. Device profiles can be used to convert colour data created on one device to the native colour space of another device. The acceptance of this format by operating system vendors allows end users to transparently transfer profiles and images with embedded profiles across different operating systems. This capability provides immense flexibility for both users and vendors. For example, it ensures that users can maintain colour accuracy when their images are transferred between systems and applications. Furthermore, it enables a printer manufacturer to create a single profile for multiple operating systems.

The purpose of the International Colour Consortium® profile format is to provide a cross-platform device profile format. Device profiles can be used to convert colour data created on one device to the native colour space of another device. The acceptance of this format by operating system vendors allows end users to transparently transfer profiles and images with embedded profiles across different operating systems. This capability provides immense flexibility for both users and vendors. For example, it ensures that users can maintain colour accuracy when their images are transferred between systems and applications. Furthermore, it enables a printer manufacturer to create a single profile for multiple operating systems (International Color Consortium, 1993).

Through the development of these profiles, the printing process is tailored to the specific paper and printer being used, with different profiles generated depending on the printer brand. The appropriate colour profile for the type of paper used in the inkjet printer is created using the i1-x-rite colour production calibration device. When a colour profile is produced, this software facilitates communication between the computer and the printer. This communication helps ensure that the colour codes of the visual display on the screen are reproduced identically by the printer. The only notable difference is that while screens operate based on RGB (light-based) colour, printers rely on the CMYK coding system (dependent on the white of the substrate), making it possible to achieve a success rate of 95% to 98% in print results, though a 100% match is typically unattainable. However, this success is made possible through the use of profiles. This can be likened to the precision required in the screen resolution of the CMYK printing process in a printing house. Naturally, it is often difficult for the eye to perceive this result. The outcome of the print varies depending on whether the paper is matte or glossy. Just as in printing house results, glossy papers exhibit higher colour gamuts, resulting in stronger colour perception and more vibrant and accurate outcomes in inkjet printing. This situation may differ according to the type of paper, and it is also possible for the final result to be assessed and concluded from the artist's perspective. Another important aspect is that there is generally a tendency to prefer matte papers in the artistic printing process. This preference may be due to their closer association with the characteristics of a canvas surface, enhancing the uniqueness of the artistic expression and presentation.

The visuals of the printing results applied to the coated handmade papers are evaluated below:

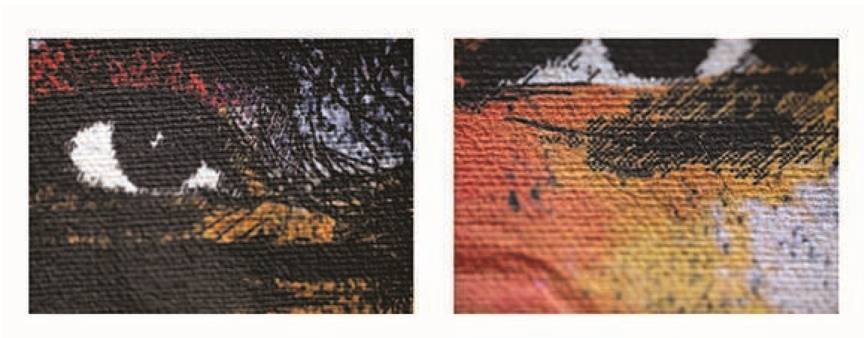
3.1 Fine Art Print Result on Linen + Cotton + Seaweed Coated Paper

A fine art print designed in 2019 by one of the researchers, Yeter Beriş, was utilized for this test print. In previous years, fine art prints of this work had been printed on Hahnemühle brand fine art paper, and the resulting prints were jointly evaluated by the artist and the printing master, Mr. Selçuk. The researchers successfully produced the first test print on paper coated with seaweed over linen and cotton, utilizing a Canon inkjet printer and generating a profile based on the natural results obtained from the i1-x-rite colour production calibration device. The initial test was positively assessed due to the accurate results attributed to the paper's coating properties (Figure 7a, b, and c).

a) b) c)

Figure 7a, b and c: Fine art printing and profile process on linen + cotton moss-coated paper

As a result of this printing process, close examination with a magnifying glass revealed that similar to other internationally recognized fine art papers, the ink density was of high quality and that the ink did not spread on the surface even in the case of the finest ink structures. Despite the natural colour of the handmade raw paper, the ability to obtain a profile in the first test print was positively received. Consequently, the formation of profiles in the initial trial and the observation during the magnification examination that the details were very sharp and that the inks did not spread were confirmed (Figure 8a and b).



a) b)

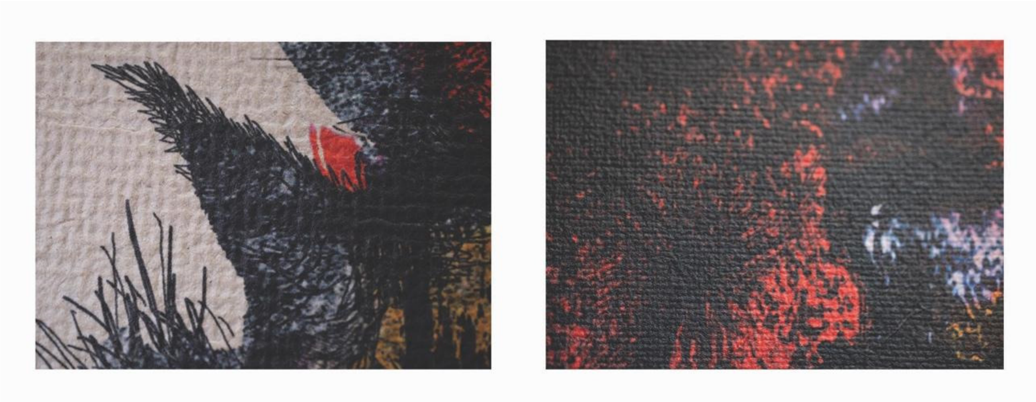
Figure 8a and b: Close-up view of the fine art print result on Linen + Cotton paper with moss coating

3.2 Fine art print result on Hemp + Seaweed coated paper

In the printing conducted on hemp moss-coated paper, as in the previous test, the first test printing was performed using the i1-x-rite brand colour production calibration device. The result was a natural profile, enabling fine art printing. Due to the coating properties of the paper, it was positively evaluated that the first test yielded accurate results, similar to those of the linen and cotton moss-coated paper (Figure 9).

Figure 9: Fine art printing and profile process on Hemp + Seaweed coated paper

As a result of this print; when the moss-coated hemp fine art print paper on which artistic printing was made was examined closely with a magnifying glass, it was observed that the ink density was high quality and that the ink structure was not damaged even as a result of the thinnest linear printing, just like the Linen+Cotton+Moss coated fine art paper, and that there was no dispersion on the surface. Although the handmade raw paper had a darker natural colour than the surface colour of the Linen+Cotton+Moss coated fine art paper, the fact that a profile could be obtained in the first test print was evaluated positively with high appreciation. In this paper, the profile formation in the first trial the sharpness of the details in the loop examination of the printing result and the ink not dispersing on the surface were met with high appreciation (Figure 10a and b).



a) b)

Figure 10a and b: Close-up view of the fine art print result on Hemp + Seaweed coated paper

3.3 Fine art print result on seaweed-coated and Uncoated Linen art paper

In this preliminary study, printing was conducted to address the question of whether it is possible to produce profiles using the natural-coloured linen fine art print paper prepared in both coated and uncoated forms, alongside algae-coated cotton-blend linen and hemp papers. Tests conducted on algae-coated or uncoated papers produced from linen, utilizing the i1-x-rite brand colour production calibration device, revealed that profiles could not be established (Figure 11). Due to its darker natural colour compared to other papers, it was unable to produce a natural profile, preventing any successful printing. The negative evaluation was based on the fact that the initial tests did not yield accurate results, unlike those obtained from the algae-coated linen-cotton or hemp-algae-coated papers, which can be attributed to the natural colour of the paper rather than its coating.

Figure 11: Fine art printing profile process on moss-coated linen paper

4. DISCUSSION

For fine art prints, the papers used must be acid-free and lignin-free to ensure structural longevity. Green algae are a suitable raw material for paper production due to their higher cellulose content compared to brown and red algae. The inks used for printing must also have a long lifespan to be accepted. Handmade papers can provide these characteristics. As seen in the visuals of the papers utilized in this preliminary study, the hemp artistic paper produced in its natural raw colour was accepted with the most positive evaluation regarding profile production and print suitability. Conversely, it was found that another artistic paper produced from linen, regardless of whether it had an Algae coating on its surface, was not suitable for profile production due to its natural raw colour. However, when blended with natural and acid-free bleaching methods or cotton to lighten its colour towards white, it was observed to be suitable for profile production and printing. Accompanying this preliminary study, the next phase aims to assess papers produced through natural and acid-free bleaching methods, allowing for re-bleaching based on the findings of this preliminary study, to be used in subsequent printing tests.

5. CONCLUSIONS

In conclusion, this preliminary study has demonstrated that seaweeds not only serve as a raw material for paper production but also as a suitable material for paper surface sizing. Turkey, being a country surrounded by seas on three sides, is fortunate in this regard. It is well known that the seaweeds we utilize have diverse applications across various fields. Notably, they are used as food due to their nutritional value, and they also have significant applications in the medical field. The positive outcomes of our study may pave the way for the exploration of new areas of application in the future. We propose that similar to other countries, efforts should be made in our country to cultivate these seaweeds beyond merely relying on those found in our seas.

6. ACKNOWLEDGMENTS

We would like to express our gratitude to Selçuk Akbulut, the founder and owner of Fine Art Sanatsal Baskı Ltd. and Aytekin Vural, for their support and interest in the execution of the prints in this preliminary study.

7. REFERENCES

Bloom, J. M. (2001) *Paper Before Print: The History And Impact of Paper in The Islamic World*. New Haven, Yale University Press.

Carnie, R. L. (2024) *The Role of Coatings in Fine Art Printing*. Available from: https://www.breathingcolor.com/blogs/news/role-of-coatings-in-fine-art-printing?srsltid [Accessed 01 September 2024]

International Color Consortium (1993) *INTERNATIONAL COLOR CONSORTIUM.* Available from: https://www.color.org/index.xalter [Accessed 8 July 2024]

Lin, J., Jiao, G. & Kermanshahi-pour, A. (2022) *Algal Polysaccharides-Based Hydrogels: Extraction, Synthesis, Characterization, and Applications.* 20 (5), 306. Available from: doi: 10.3390/md20050306

Moral, A., Aguado, R., Castelló, R., Tijero, A. & Ballesteros, M. (2019) Potential Use of Green Alga Ulva sp. for Papermaking. *BioResources*. 14 (3), 6851–6862.

Mukherjee, P. & Keshri J. P. (2018) Present status and development of algal pulp for hand-made paper making technology: a review. *Advances in Plants & Agriculture Research.* 8 (1), 10–18. Available from: doi: 10.15406/apar.2018.08.00284

Özden, Ö. (2018) *Sızdırmazlık Özelliği Kazandırılmış Ambalaj*. Turkish Patent Institute, Turkey.

Sulastri, E., Zubair, M. S., Lesmana, R., Mohammed, A. F. A. & Wathoni, N. (2021) Development and Characterization of Ulvan Polysaccharides-Based Hydrogel Films for Potential Wound Dressing Applications. *Drug Design, Development and Therapy*. 15, 4213–4226. Available from: doi: 10.2147/DDDT.S331120

Wahlström, N. (2020) *Polysaccharides from Red and Green Seaweed: Extraction, Characterization, and Applications*. Doctoral Thesis. KTH Royal Institute of Technology, Department of Fibre and Polymer Technology, Stockholm, Sweden.