RESEARCH ARTICLE

Tamarind (*Tamarindus indica L.*) Charcoal Color for the Use in Woodcut Printmaking

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Abstract

This research aimed to study the quality of color produced from tamarind (*Tamarindus indica L.*) charcoal for use in woodcut printmaking and to compare the color fastness of woodcut prints on various types of paper by examining four color formulas blended with mixtures of Arabic gum and tamarind seed gum. The results revealed that Fabriano paper was the most suitable material for woodcut printmaking using tamarind charcoal color, particularly with Formula 1, which consisted of tamarind charcoal powder, Arabic gum, glycerin ($C_3H_8O_3$), honey, and deionized water (H_2O), as well as Formula 2, which additionally contained indigo (*Indigofera tinctoria L.*) powder. The comparison of hue and fastness, as determined by a colorimeter, showed that Formula 2 on Fabriano paper exhibited the highest L* value and intensity at 20.80. The +a value indicated a shift toward the green zone, while the −b value indicated a shift toward the blue zone, reaching its highest level at −1.90 due to the addition of indigo powder. Moreover, the average intensity (L* value) on Fabriano paper across the four color formulas showed consistent results. Applying these colors in the woodcut printmaking process demonstrated smooth hues with high intensity, durability, and detailed color expression. In contrast, the color blended with tamarind seed gum showed unstable endurance when applied with a paint roller, resulting in unclear details and hues due to color coagulation. All four color formulas demonstrated good solubility and could be used with either water or deionized water as solvents.

1. Introduction

Color is considered a crucial factor in creating artwork. Printmaking, a branch of art, requires color as an integral element in crafting a piece, using either water-based or oil-based colors. However, the use of chemical colors is often detrimental to the artists themselves during and after the creation of artworks due to color odor. A considerable number of artists have died as a result of cumulative exposure to color chemicals and volatile substances released during mixing, washing, and cleaning materials and equipment used in creating artworks (Kiatajin, 2012). Currently, there is a growing trend toward using natural colors in printmaking. The works of Yanawit Kunjaethong, a lecturer at the Faculty of Painting, Sculpture and Graphic Arts, Silpakorn University, have incorporated natural colors in his collection of organic prints titled "Print from Forest," which used flowers, leaves, fruits, roots, bark, pith, and other parts of plants such as the bark of pussy willow, red sandalwood, *Pueraria mirifica*, or colors derived from shellac, ebony, and indigo. In this collection of organic prints, the artist presents an abstract narrative through lines, color drops, and brushwork, reflecting the mood and beauty of nature—flowers, grasses, streams, sky, time, and seeds—expressed in his printmaking works (Kiatajin, 2012).

The approach of using natural colors in printmaking is considered an innovative and valuable artistic method. This self-reliant production of art materials, grounded in local wisdom, is safe for both health and the environment. It reduces the use of chemicals in oil-based printing inks and decreases dependence on imported printing inks. Additionally, it supports environmental management through conservation, restoration, and sustainable utilization of natural resources (Sathaporn, 2012). Natural colors are increasingly reused in artworks such as fabric dyeing, painting, and printmaking.

The evolution of color usage has a long history. In Chinese painting, for example, two main types of black ink—ink stick and ink stone—were produced. The ink stick was made from pine charcoal or soot mixed with glue and camphor, then pressed into sticks that needed to be rubbed on rock with water before use. The ink stone was made from Duan stone located at Mount Fuki, a hard, impermeable stone with a fine black texture (Tepsing, 2005). Ancient Chinese color usage suggested that colors in Chinese paintings were classified into six categories: color from minerals, plants, animals, synthetic materials, mixed colors, and metals.

A study on color media for mixing color powders in ancient paintings identified two main types: glue and alum. Glue obtained from animals, such as cowhide glue, was suitable for mixing with color powders for painting. Fish glue, known for its stickiness, was commonly used in woodwork, while plant glue was used for coating containers, household decorations, and musical instruments. Alum was used to improve color fastness, preserve painting surfaces, and prolong painting lifespan (Su and Saengprom, 2021).

The use of natural colors has significantly declined due to the convenience of chemical colors. Previous research on natural dye formulas for printmaking developed natural inks from plants in Nakhon Si Thammarat Province. Experiments aimed to find a suitable formula for natural ink using a mixture of natural color extract, mordant, and tapioca starch in a ratio of 3:1:1 for woodcut printmaking on paper and cotton fabric. The results showed that plant-based extracts could be used for image printing when properly thickened. Tapioca starch was found to be more suitable than fresh Para gum (Sathaporn, 2012).

Incha (Inchar, 2019) studied natural color extraction for printmaking and proposed three different methods: (1) mixing color in natural solvents such as alum, salt, or rust to aid adhesion and durability; (2) mixing color with compounds such as rust, mud, limewater, or calcium hydroxide; and (3) processing materials to produce color, such as drying and powdering soot or mud. Charcoal is one of the most interesting materials for producing color because it is locally available and widely used as fuel for household cooking. Hardwoods such as mangrove, tamarind, and acacia are commonly used to make charcoal because they produce strong, durable charcoal that is not brittle.

Charcoal has many beneficial properties, including moisture protection, soil nourishment, and odor absorption. Research on factors affecting the efficiency of odor-absorbing rubber sheets found that increasing the amount and particle size of charcoal enhanced odor adsorption efficiency. Tamarind charcoal provided the best odor absorption, followed by mixed wood charcoal and bamboo charcoal, with efficiencies of 33, 32, and 29 ppm, respectively (Pansuwan et al., 2012). This finding aligns with research investigating smokeless briquettes using binders derived from polystyrene and polypropylene plastic waste. Tamarind charcoal powder mixed with liquid plastic binder in different ratios improved the performance of smokeless briquettes. Tests showed that tamarind charcoal briquettes had high compressive strength and rigidity, providing prolonged heat without breaking easily. The binder also dispersed well within the briquettes, creating compact charcoal particles capable of withstanding high compression (Somdee et al., 2016).

Tamarind charcoal is therefore a promising material for developing color for artworks, as it is easy to obtain, has a strong texture, deep black tone, and resists brittleness. Digital technology is applied through the use of a color measurement device (colorimeter), providing a reliable system for assessing fundamental color properties such as brightness and fading, which inform the production process of natural pigments. This plays a crucial role in determining color values and intensity. The device measures L*, a*, and b* values in the CIE Lab* color space—a three-dimensional system in which L* represents lightness, a* denotes the red-green axis, and b* represents the yellow-blue axis (Sulong, 2024). The CIELAB color space diagram is shown in Fig. 1.

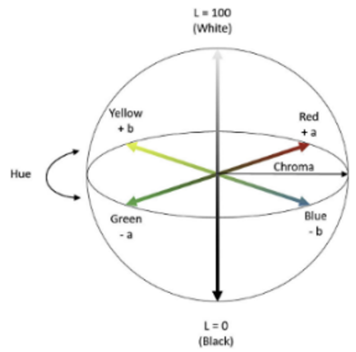

Figure 1. The CIELAB color space diagram.

In comparing hue values on paper, this research employed a colorimeter to measure lightness values using the L*-a*-b* system, where L* represents lightness from white (+L*) to black (–L*) on a scale of 1–100, a* represents the axis from green (–a*) to red (+a*), and b* represents the axis from blue (–b*) to yellow (+b*).

In educational contexts, using chemical-based or pre-made colors for children and students presents several health and safety concerns. Many chemical dyes and pigments contain substances that can be harmful if ingested, inhaled, or absorbed through the skin—posing risks especially for young children. Exposure to these substances may cause allergic reactions, skin irritation, respiratory issues, or long-term health effects with frequent use. Therefore, it is essential to promote safe and sustainable practices by exploring non-toxic, natural color alternatives that minimize these risks while fostering a safe and creative learning environment.

Thus, the researcher was motivated to explore the knowledge and production process of color derived from tamarind charcoal for use in woodcut printmaking. The color was produced and tested to compare the quality of color fastness in woodcut printmaking works. This approach is expected to reduce the use of chemical colors, while its results can be applied to further color development and experimentation in other art disciplines.

2. Objective

The objectives of this research are as follows:

1. To examine the quality of color produced from tamarind charcoal for use in woodcut printmaking.
2. To compare the color fastness of woodcut printmaking on different types of paper.
3. To apply digital technology to accurately measure color values using a colorimeter.

3. Materials and Method

3.1 Materials

- Tamarind charcoal powder — 40 g
- Glycerin — 50 ml
- Arabic gum — 20 g
- Tamarind seed gum — 20 ml
- Indigo powder — 10 g
- Honey — 36 ml
- Deionized water — 48 ml

3.2 Equipment

- Glass muller
- Glass plate
- Woodcut tools
- Wood board
- Roller
- Trowel paper
- Color storage jar
- Wet sandpaper
- Ceramic mortar
- Paintbrush screen
- Cotton sheet

3.3 Research Methodology

The research methodology employed an experimental process using four mixture formulas as described below.

Formula 1: Tamarind charcoal powder with Arabic gum

- 10 g fine tamarind charcoal powder
- 10 g Arabic gum
- 10 ml glycerin
- 8 ml honey
- 12 ml deionized water

Formula 2: Tamarind charcoal powder with Arabic gum and indigo powder

- 10 g fine tamarind charcoal powder
- 5 g indigo powder
- 10 g Arabic gum
- 15 ml glycerin
- 10 ml honey
- 12 ml deionized water

Formula 3: Tamarind charcoal powder with tamarind seed gum

- 10 g fine tamarind charcoal powder
- 10 g tamarind seed gum
- 10 ml glycerin
- 8 ml honey
- 12 ml deionized water

Formula 4: Tamarind charcoal powder with tamarind seed gum and indigo powder

- 10 g fine tamarind charcoal powder
- 5 g indigo powder
- 10 g tamarind seed gum
- 15 ml glycerin
- 10 ml honey
- 12 ml deionized water

3.4 Preparation Procedure

1. Grind the tamarind charcoal by rubbing it on sandpaper and sifting it through a screen before use.

2. Dry the fermented indigo, finely grind it using a ceramic mortar, and sift it through a screen before use.

3. Prepare two types of glue:

   (a) Arabic gum: finely pre-ground acacia gum, ready for use.

   (b) Tamarind seed gum: prepared by boiling powdered gum over low heat in a ratio of 20 g tamarind gum to 200 ml water, then filtering through a cotton sheet to obtain 100 ml of liquid glue.

4. Honey: use pure longan pollen honey, a product of Doi Kham.

5. Distilled water: use deionized water.

3.5 Operation Process

1. Mix the color according to the formula by first placing tamarind charcoal powder on a glass plate. Add Arabic gum or tamarind seed gum and honey, then gradually add deionized water according to the ratio while mixing with a trowel. Use a glass muller to grind the mixture on a glass or ceramic plate until it is homogeneously blended, then store it in a plastic jar for further use.

2. Create the woodcut printmaking work by preparing a block of hardwood and sketching an image on it. Use woodcut tools to carve the image into the surface of the hardwood. When rolling the color over the block and printing onto paper, the color will not appear on the carved parts but will appear on the non-carved areas, producing a reversed image from left to right.

3. Sketch the image and carve it into the hardwood. Use a roller to apply one color formula at a time onto two types of paper, namely 200 gsm fine paper and Fabriano paper, which contains 50% cotton.

4. Measure the color values (hue and fastness) on the color-printed papers to compare color intensity and fading. Evaluate the L* value (lightness) in the CIELAB color system, which ranges from 0–100, as well as a* and b* values indicating color direction: +a* for red, –a* for green, +b* for yellow, and –b* for blue, using a colorimeter.

4. Results and Findings

The results of the study on the information and creation of artworks using color derived from tamarind charcoal in woodcut printmaking revealed the following:

4.1 Examination of the Quality of Color from Tamarind Charcoal Used in Woodcut Printmaking

The quality of color texture on paper printed with the four color formulas demonstrated that the color made from tamarind charcoal blended with Arabic gum in Formula 1 and Formula 2 produced a smoother and more even color texture than that blended with tamarind seed gum. It also provided clearer patterns on Fabriano paper, which contains 50% cotton, compared with 200 gsm fine paper. Printing with color from tamarind charcoal mixed with indigo powder (from indigo blue fine-textured mud blended with calcium hydroxide in water and air-dried) resulted in a softer printing color. When more water was added, the indigo color appeared among the black color, adding more dimension to the work. Similarly, Inchar (2019) reported the discovery of natural colors used in printmaking techniques with gelatin plates. Among several methods were pounding, grinding, smashing, and fine grinding of colored plants and mixing them with water or compounds to cause color reactions, such as rust, mud, limewater, and calcium hydroxide. The mixture was then squeezed and filtered to obtain only the colored liquid for use, without boiling or heating. This method was mainly used for plants that required a long reaction time for color extraction. Alternatively, in fabric dyeing, a method known as the cold dye technique also used natural colors without applying heat. In that research, various plant colors were used, including those derived from pot bottom soot and indigo.

The quality of the color texture derived from tamarind charcoal suggested that tamarind charcoal powder blended with Arabic gum in Formula 1 and Formula 2 offered good viscosity and could be diluted with deionized water to produce lighter tones. The color texture prepared from tamarind seed gum blended with tamarind charcoal powder was initially well mixed into a fine texture but tended to clump after a short period. The presence of shreds in the color texture caused unevenness when used to create artworks, resulting in less smooth finishes.

A comparison of color texture quality using a colorimeter to measure hue values found that the color from tamarind charcoal in Formula 1 on Fabriano paper (50% cotton) showed the highest L* value at 20.80, with a +a* value directed toward the green zone and a –b* value directed toward the blue zone at the highest level of –1.90, due to the addition of indigo powder. Moreover, with the mixed indigo powder, the –b* value was also observed in Formula 4, which used tamarind seed gum on Fabriano paper. The average intensity indicated that the L* value and color intensity on Fabriano paper (50% cotton) were consistent across all color mixture formulas.

4.2 Comparison of Color Fastness

According to Fig. 2, the comparison of color fastness on different papers suggested that the color from tamarind charcoal blended with Arabic gum in Formula 1 and Formula 2 produced smoother and more even colors in woodcut printmaking compared with the color blended with tamarind seed gum. The printed patterns were also clearer on Fabriano paper containing 50% cotton than on 200 gsm fine paper.

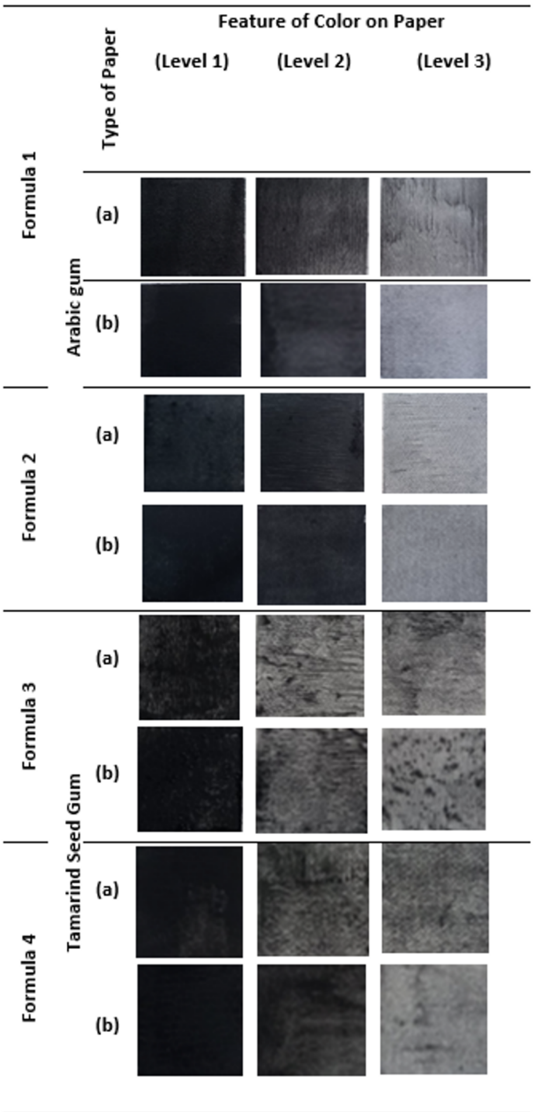

Figure 2. A comparison of color fastness on different types of paper for the 4 formulas of blended colors from tamarind charcoal.

5. Discussion

A comparison of the differences between the color blends and deionized water solvent in two ratios of color to deionized water, 10:2.5 (producing color level 2) and 10:5 (producing color level 3), is shown in Fig. 3.

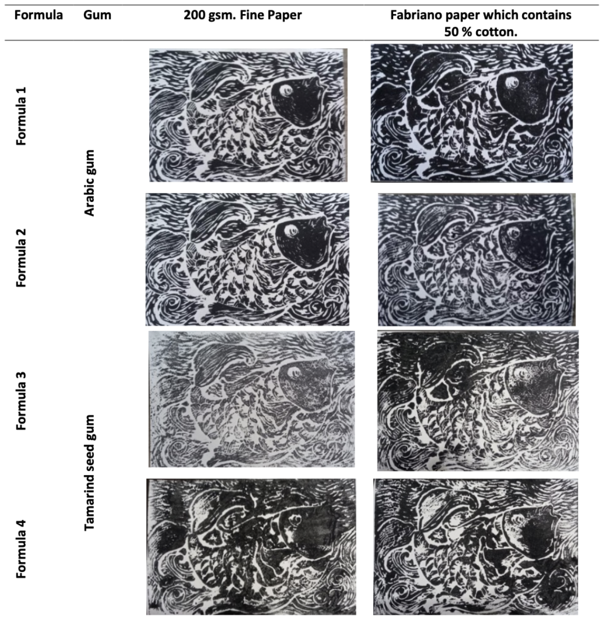

Figure 3. Reduced values of hue with deionized water solvent, and roller applying colors on 2 different types of paper: paper (a) as 200 gsm. fine paper, and paper (b) as Fabriano paper which contains 50% cotton.

According to Fig. 3, the hue values appearing on papers using the four color formulas were observed under three different concentration levels: Level (1) with the original concentration as per the formula, Level (2) mixed with a moderate amount of deionized water, and Level (3) mixed with a high amount of deionized water. It was found that the formulas blended with Arabic gum (Formula 1 and Formula 2) produced smooth and even color textures, while Formula 3 and Formula 4, blended with tamarind seed gum, resulted in dense color stains lacking smoothness and showing coagulation. All color formulas could be diluted using deionized water as a solvent.

According to Table 1, which compares hue measurements, the color from tamarind charcoal in Formula 2 on Fabriano paper (containing 50% cotton) showed the highest lightness (L*) value at 20.80, with the +a* value directed toward the green zone and the –b* value directed toward the blue zone at the highest level of –1.90, resulting from the addition of indigo powder in this formula. Furthermore, the inclusion of indigo powder also produced a noticeable –b* hue value on Fabriano paper (50% cotton) in Formula 4, which was blended with tamarind seed gum.

Table 1. Measuring the hue values with colorimeter to compare the value of lightness and hue (L*a*b*) for 3 different levels of colors with the test on 2 different types of papers: paper (a) as 200 gsm. fine paper (b) as Fabriano paper.

Formula	Paper	L*	a*	b*	-a*	-b*	+a*	+b*	-a	-b
3	(a)	35.20	46.10	47.20	-1.00	-0.90	-0.80	0.00	0.10	0.00
3	(b)	28.00	43.60	49.90	-0.60	-0.40	-0.40	-0.60	-0.30	-0.40
4	(a)	29.10	36.20	45.50	-1.10	-1.00	-0.90	-1.30	-0.60	-0.10
4	(b)	27.30	33.20	49.90	-0.80	-1.00	-0.70	-1.70	-1.20	-0.30

Table 2. Measuring the hue values after 16 weeks with Colorimeter to compare the value of lightness and hue (L*a*b*) for 3 different levels of colors with the test on 2 different types of papers: paper (a) as 200 gsm. fine paper (b) as Fabriano paper.

Formula	Paper	L*	a*	b*	-a*	-b*	+a*	+b*	-b
3	(a)	35.20	46.10	47.20	-1.00	-0.90	-0.80	0.00	0.00
	(b)	28.00	43.60	49.90	-0.60	-0.40	-0.40	-0.60	-0.40
4	(a)	29.10	36.20	45.50	-1.10	-1.00	-0.90	-1.30	-0.10
	(b)	27.30	33.20	49.90	-0.80	-1.00	-0.70	-1.70	-0.30

According to Table 2, after 16 weeks, the brightness (L*) values of all mixing formulas increased. The color from tamarind charcoal mixed with Arabic gum exhibited the highest color value in the red direction (+a*) in Formula 1 on Fabriano paper, with a level of 25.30.

6. Conclusion

In applying natural colors to the creation of artworks, the researcher believes that there are many other approaches to developing colors for artistic use. Moreover, colors from various natural sources such as soil, rocks, and plants should be further explored since they are naturally available and can be enhanced through the integration of local wisdom. The process of developing natural colors is not too complex or difficult, allowing for deeper learning about the hues and beauty of plants and natural materials. Colors derived from plants are exquisite, light in tone, unique, and provide different shades when their pigment values are measured. According to the study of natural color extraction for painting, measuring color values using a Digital Image Colorimeter (DIC) revealed that yellow was found within red extracted from sappan (*Caesalpinia sappan L.*) using ethanol on 300 gsm paper, which yielded red, green, and blue values of 0.87, 0.59, and 0.48, respectively (Narongdecha and Soodsang, 2019).

Digital technology played an important role in this study by providing precise measurements of color values. A colorimeter is an instrument designed to measure and quantify the light emitted or reflected from a sample, primarily used to detect color variations between a production sample and a predefined color standard. It is widely used across various industries for comparative color quality control to ensure consistency and compliance. Applications include calibrating displays and computer monitors, assessing automotive interior components, evaluating food products, maintaining quality in color printing, and monitoring textile and paint manufacturing processes (Phillips, 2024). This also aligns with the application of colorimetry in the food industry, where various color models such as CIE LAB and RGB are predominantly used due to their close alignment with human color perception (Dutta and Nath, 2023).

In this study, Formula 1 (tamarind charcoal powder with Arabic gum) and Formula 2 (tamarind charcoal powder with Arabic gum and indigo powder) applied on Fabriano paper produced smooth textures with well-diluted characteristics. In addition, the inclusion of honey helped improve the color's durability. This corresponds with the findings of Narongdecha (2022), which stated that mixing water in color extracted from annatto seeds helps reduce mold formation after blending. When the color mixture was stored for approximately six weeks, the quality of the color texture from annatto blended with honey was found to extend usability. Furthermore, color powder from annatto seeds mixed with glycerin showed the lowest fastness. Glycerin is a highly beneficial substance used in many industries, such as an ingredient to enhance moisture in cough syrups, food, and cosmetics (Chanunpanich et al., 2009).

In this research, the use of tamarind charcoal color in woodcut printmaking was found to have no strong odor and could be easily washed. The colors left no stains on the hands of creators, and the ingredients were safe for users. The developed color can be applied to various types of artwork, including painting.

The following recommendations are proposed for further studies:

- Conduct research on more plant species that can be used to develop a wider variety of colors.
- Invent ingredients that can prevent colors from becoming easily degraded or moldy.

- Emphasize the sustainable use of local plants while avoiding the destruction of forests and the depletion of natural food sources.

- Consider conservation and replanting when using plants, avoiding the use of stems and roots.

- Develop color products in packaging suitable for preservation and ease of use.

- Improve color formulas to ensure better adherence to materials such as fabric.

Appendix: Illustrations of Experimental Process

This section illustrates the experimental process, starting from the fine-ground tamarind charcoal powder prepared for color production, blending the color powder with finely ground indigo powder, preparing materials and tools for woodcut printmaking, rolling color onto the created woodcut work, and applying the color formulas for printmaking on crepe paper and other types of paper in teaching activities, as shown in Fig. 4 to Fig. 9.

Figure 4. Fine-ground tamarind charcoal powder.

Figure 5. Blending color powder with ingredients fine-ground indigo powder.

Figure 6. Preparation of materials and tools for woodcut.

Figure 7. Rolling color onto the created woodcut work process of work creation consisted of (2) Creating work by preparing a wood board for printmaking; (3) Carving into the wood board as the design sketch .(4) Rolling color onto the block of wood board, and trying out printing each formula one by one; and (5) Testing the quality of colors after printing on 2 different types of paper.

Figure 8. Applying usage of color in teaching and learning for kids.

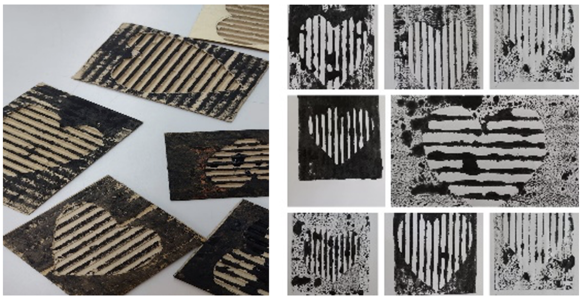

Figure 9. Applying color formula for printmaking on crepe paper and paper respectively in teaching activity.

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