



Extracting Natural Colors from Marigolds for Watercolor Painting in Interior Architecture

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ABSTRACT

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Color is one of the essential factors in daily life, and humans have used natural pigments since prehistoric times, derived from locally available natural materials. However, synthetic dyes produced industrially have been developed to replace natural pigments and have gained popularity, leading to the decline of natural pigment usage. Flowers are widely available natural materials that provide pigments. Marigolds are a popular flower among Thai people because they are easy to grow and cultivate. They can be cultivated year-round and produce vibrant, long-lasting flowers. In the Vishnukarman offering ceremony, a significant number of marigolds are left over after worship. The research team extracted natural colors from marigolds by hot extraction or boiling to develop watercolors. Experiments have shown that marigolds can be used to extract pigments through boiling. The natural pigment extraction from marigolds was conducted through hot extraction at 140°C for 30 minutes using three methods to compare the resulting yellow intensity. It consists of 1) whole marigolds, 2) fine marigolds, and 3) yellow petals. It was found that method 3 gave the most vivid yellow water, and the water color on the paper was brighter. Method 3 was further tested through repeated boiling at 140°C in three sessions of three minutes each. It was found that the first boil gave the most clear colored water, and when the next boil it was more turbid, it became more turbid respectively. In conclusion, natural pigment extraction from marigolds through hot extraction can effectively produce watercolor paint. Using only yellow petals boiled at 140°C for three minutes yields a bright yellow pigment. This method allows individuals to create their own watercolor paint from natural materials without relying on commercial products.

1. INTRODUCTION

Natural pigments have been used for centuries in art and design, offering eco-friendly and non-toxic alternatives to synthetic dyes [1]. However, challenges such as low stability [2] and limited availability have hindered their widespread adoption. Marigolds (*Tagetes* spp.), a common ornamental and ritual flower in Thailand, hold promise as a sustainable source of natural yellow pigments (Figure 1). Other plants in the same family as marigolds include chrysanthemums, zinnias, and other Asteraceae species [3]. The marigold is a short-lived flowering plant with a stem height of approximately 2–4 feet. The flowers are head-shaped. There are both double and non-stacked flowers, orange, yellow, and bright colors. The marigold is a popular plant because it is easy to grow and cultivate. It can be grown all year round and has beautifully shaped, colorful flowers and blooms for several days. Marigolds are widely cultivated in Thailand due to their fast growth, long blooming period, and minimal care requirements. It doesn't require much care. It can be grown in all regions of the country and all year round. In addition to being cultivated as ornamental flowers, marigolds have also been traditionally used as a natural dye for fabrics since ancient times [4]. In Buddhist traditions, Thai people use marigold garlands to pay

homage to monks. In rituals, a lot of marigolds are used. After using marigolds for worship for at least 3 days, they are thrown away.



Figure 1. Marigolds

Therefore, the research team saw the importance of using the remaining marigolds from this worship to develop them for their benefit by extracting natural colors from marigolds by hot extraction by boiling to develop into watercolors. This study aims to investigate the feasibility of extracting pigments from used marigolds and to determine the most effective extraction methods. To obtain a bright yellow color that can be used to write watercolor in interior architecture on paper and not fade. To enhance the presentation of interior architectural works

using natural materials. To develop and disseminate the knowledge gained to the community to increase the value from the belief in auspiciousness from marigolds that are worshipped to the gods and angels at various important ceremonies.

The objectives of this study are:

1. To study the history of natural colors.
2. To study how to extract natural colors.
3. Experiment with natural color extraction for watercolor painting in interior architecture.

The research scope includes:

1. Study the history of natural paints.
2. Study of natural color extraction methods.
3. Experiment with natural color extraction for watercolor painting in interior architecture.

2. LITERATURE REVIEW

2.1 History and meaning of colors in Thailand

Thai people have been using natural pigments for more than 1,500 years. Evidence includes paintings on cliff walls, stone tablets, and pottery. These artworks depict human activities of that time, utilizing brown pigments derived from soil mixed with milk, as well as dyes extracted from various plants [5]. Ancient pigments were typically obtained from natural sources in powdered form, including earth, stones, minerals, plants, and animals [6]. These materials were ground into a fine powder and mixed with glue derived from animal skins and bones, allowing the paint to adhere to surfaces and resist peeling. Thai painters preferred to use tamarind and acacia glue. Initially, they used only a limited palette of colors. This palette was known as Ekrong, consisting of white, black, and red. Later, an additional five colors were introduced, known as Benjarong or Krayarong, including yellow, indigo, red, white, and black. These colors were used as primary pigments and mixed to create a wider range of hues. Later, pigments were imported from abroad, including China and other foreign regions, further expanding the color variety. These imported pigments were referred to as Phahurong, including Tangchae green and Lychee red [7]. Over time, these pigments fade into specific shades, such as reddish or yellowish tones. In traditional Thai paintings, the protagonist was often highlighted by applying gold leaf to enhance its brilliance and prominence. It represents unity and faith. In addition, various colors are also used to represent characters in various Thai literary stories, such as the green Indra, the white Hanuman, etc.

2.2 Influence of color

Color influences emotional expression [8] and is a crucial element in visual arts [9].

Color has a psychological impact as it transmits visual information to the brain, triggering emotional responses [10]. Feelings such as freshness, excitement, enthusiasm, coldness, etc. The influence of color can be divided into two types as follows:

- Natural influences
- Influence influenced by artists or designers

2.3 Types of colors

There are two types of colors found in our surroundings: naturally occurring colors and man-made colors.

2.3.1 Naturally occurring colors

Naturally occurring colors are those inherent in objects such as the sky, the sea, trees, leaves, human skin, and animal pigmentation.

2.3.2 Man-made paints

Man-made colors are artificially produced. The use of natural pigments dates back over 2,000 years. Tyrian purple was first extracted from sea snails. The name comes from the city of Tyre. This dye was extracted from the mucus of Murex Sea snails, requiring up to 12,000 snails to produce just 1.4 grams of pigment. Due to the complex and time-consuming nature of the extraction process, Tyrian purple was reserved exclusively for royalty. It is the oldest, most expensive color. It represents the wealth of the wearer. In 1969, a number of purple powders were discovered, thought to be used in cosmetics and as pigments in murals [11]. Man-made colors are divided into two types: natural and synthetic [12].

(1) Natural colors: Natural colors are naturally derived colors, mainly from plants and animals, but are unstable to heat, light, acidity, alkalinity, enzymes, and metals [13]. Colors obtained from nature, such as shellac, okra, fuchsia, and ripe cabbage. Chinese red rice, fang, pea flower, bird's blood potato, red beet, crocato, pandan leaf, leaves of the flower of Karnika Turmeric, sugar balls, safflower, gardenia, saffron, etc. [14]. It is popular to use natural colors from plants to dye fabrics because almost all parts of the plant can be used to extract colors, including flowers, leaves, roots, bark, fruits, seeds, or it may come from soil and stones [15].

(2) Synthetic paints: All synthetic paints contain chemicals that may be potentially harmful to human health. Prolonged exposure can lead to chemical accumulation in the body, posing health risks.

Therefore, when comparing the use of natural watercolor with synthetic watercolor in interior architecture, The use of natural watercolor is all natural and can be easily produced from materials close to you by yourself. A key advantage is that natural watercolors are environmentally friendly [16]. Although they are less stable and durable than synthetic paints, their organic composition gives them a unique aesthetic appeal in art and interior architecture. However, synthetic watercolors contain chemicals that make them difficult to decompose, toxic to the environment, and carcinogenic. Although it is convenient, fast, colorful, and standard.

2.4 Natural color extraction

According to a review of the literature related to natural color extraction, it was found that:

Study on the effect of extraction method and mordant type on dye quality and study of substances in marigold dye. The natural mother color (yellow) from marigolds was studied for dyeing on cotton threads by heating and microwave techniques, and mordant was used to dye cotton threads to increase the color absorption value. Increased color absorption, darker shades of cotton threads [17].

Study of characteristics and properties of dye powder from marigold petals. By adding different amounts of sodium chloride and sodium sulfate, the humidity. It is applied to cotton and silk with experimental pigments [18].

Study of fabric dye powder from pean, okra, calendula, and pandan leaves on absorbent. The effectiveness of fabric dye powder from peanut, okra, calendula, and pandan leaves was studied using water as a solvent by three types of absorbent substances, namely chalk, silica gel, and bentonite clay, to help

increase the effectiveness of color adhesion on fabric fibers. Comparison of light absorption and color absorption before and after of fabric dye powder [19].

Study of natural objects that provide color for use in the creation of Thai paintings. The study studied natural objects specific to the color group obtained from 9 plants, including fang, turmeric, marigold, rongtong, mango, indigo, eucalyptus, Rajapruek, and coconut. It is extracted by boiling, fermenting, and grinding it into natural water and precipitating it into a color powder to be used in painting damaged Thai temple murals [15].

According to the relevant literature review, natural colors from marigolds have been extracted for dyeing fabrics and the food industry, and other natural colors have been extracted for murals. The extraction of color from marigolds into watercolor for use in interior architecture has not been found.

According to a review of research related to natural color extraction, it was found that natural color extraction can be done in two ways: extraction with water or solution and dry extraction, as follows:

2.4.1 Extraction with water or solution

There are 2 methods of extracting colored water:

(1) Boiling natural materials with water starts by boiling natural materials and water in a ratio of 1:5 at a temperature of 80 degrees Celsius for 1-2 hours, then filtering to leave only colored water. Boil this colored water 1-2 more times until 1/3 of the colored water remains, let it cool, then put the colored water in a closed container.

(2) Start with pounding or blending natural materials, then mix them with water 10-20 times by weight, then squeeze or filter them to leave only colored water (Apply to fresh natural materials.)

2.4.2 Dry extraction

It is an extraction to obtain a pigment that must be extracted into a pigment from the above steps to be extracted into a pigment powder. There are 3 ways as follows:

(1) Drying: drying the colored water at a temperature of 50 degrees Celsius for 6-8 hours or until the colored water is completely dry and then crushing it into a colored powder.

(2) The use of absorbent salt is made by taking colored water in installments with sodium chloride salt, simmering until dry, and then grinding it into a colored powder.

(3) Salt precipitation: Mix the colored water with 15% sodium chloride salt, stir well, let the colored water settle, then put it in a precipitation centrifuge for 10 minutes, then filter it with filter paper to retain the sediment, then bake and grind it into a colored powder [20].

3. RESEARCH METHODOLOGY

3.1 Research instruments

Experimental equipment: Pot, gas stove, ladle, thin white cloth, watercolor paper, and brush.

Experimental materials: Marigolds, water, and alum.

Photos of experiments in which the research team experimented with the extraction of natural colors from marigolds for watercolor painting in interior architecture.

3.2 Data collection

Natural pigments were extracted from marigolds using the boiling method under three different conditions:



- 1. **Whole petals:** Marigold petals were used without any prior processing.
- 2. **Crushed petals:** Marigold petals were finely ground before extraction.
- 3. **Yellow petals only:** Green and black parts of the petals were removed, leaving only the yellow portions.

General Extraction Procedure:

- 1. **Preparation:** 100g of marigold petals (as per the selected method) were placed into a container.
- 2. **Boiling Process:** 400g of clean water was added, and the mixture was boiled over low heat for 30 minutes. Changes in water color were observed throughout.
- 3. **Filtration:** After 30 minutes, the pigment extract was strained using a fine white cloth to remove solid residues. The resulting pigment solution was collected in a container.
- 4. **Application Test:** A brush was used to apply the extracted pigment onto paper to evaluate color intensity and freshness.

After completing all three experiments, the extracted colors were compared in terms of vibrancy and intensity when applied to paper.

Table 1. Extraction of color from whole marigold petals by boiling

Procedure	Picture	Experiment Details
1		Knock out the marigold petals from the stem. Put in a prepared container in the amount of 100 grams.
2		Prepare to extract the color from the marigolds by boiling. Put the ingredients on the stove, pour 400 grams of clean water into a pot, add the prepared marigold petals, and boil over low heat.

3



Boil the marigolds for 30 minutes. After 20 minutes, the color becomes darker; boil until 30 minutes are complete.

4



When 30 minutes are up, turn off the stove and strain the marigold juice with a thin white cloth into a container. Remove only the colored water and remove the marigold flesh. The resulting water color is clear yellow.

5



Use a brush to dip the colored water and drain it on the paper.

Table 2. Extracting color from whole marigold petals that have been pounded and boiled





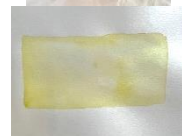
Procedure	Picture	Experiment Details
1		Pick 100 grams of marigold petals from the stem and take the marigolds and pound them finely. Put in a prepared container.
2		Prepare to extract the color from the marigolds by boiling. Put on the stove, pour 400 grams of clean water, put in a pot, add the prepared marigold petals, and boil over low heat.
3		Boil the marigolds for 30 minutes. After 20 minutes, the color becomes darker; boil until 30 minutes are complete.
4		When 30 minutes are up, turn off the stove and strain the marigold juice with a thin white cloth into a container. To remove only the colored water and remove the marigold flesh. The resulting water color is dull yellow or brownish.
5		Use a brush to dip the colored water and paint it on the paper.

Table 1 demonstrates the extraction of color from whole marigold petals by boiling. The extraction of color from whole marigold petals was carried out by boiling them in a 1:4 ratio of water for 30 minutes. After 10 minutes, the water turned yellow. When tested on paper, the color appeared slightly yellowish with a greenish tint. By the 20th minute, the water had deepened to a greenish-yellow shade, which remained

stable even after continued boiling for 30 minutes, despite some evaporation.

Table 2 demonstrates the extracting color from whole marigold petals that have been pounded and boiled. A second experiment was conducted using whole marigold petals and pounding them under the same conditions. The resulting color was a dull yellow or brownish.

Table 3. Extraction of color from marigolds only yellow petals by boiling






Procedure	Picture	Experiment Details
1		Use scissors to cut the marigold petals so that they do not stick to the young stem parts of light green and black color. 100 grams in a prepared container.
2		Prepare to extract the color from the marigolds by boiling. Put on the stove, pour 400 grams of clean water, put in a pot, add the prepared marigold petals, and boil over low heat.
3		Boil the marigolds for 30 minutes. After 20 minutes, the color becomes darker; boil until 30 minutes are complete.
4		When 30 minutes are up, turn off the stove and strain the marigold juice with a thin white cloth into a container. Remove only the colored water and remove the marigold flesh. The resulting water color is clear yellow.
5		Use a brush to dip the colored water and paint it on the paper. It is bright yellow, and there are no other colors mixed in.

Table 3 demonstrates the extraction of color from marigolds only yellow petals by boiling. The resulting color was a clearer and more vibrant yellow. Among the three extraction methods, boiling only the yellow petals yielded the most vivid yellow pigment, while whole petals resulted in a darker, less vibrant shade.

To verify the optimal method, the process was repeated by re-boiling the same batch of marigolds three times. Additionally, alum was added to compare the differences between marigold and calendula extracts, with further painting tests conducted.

4. RESULTS

The results of the study on the extraction of natural colors from marigolds for watercolor painting in interior architecture with the following objectives: 1) study the history of natural colors, 2) study the method of extracting natural colors, and 3) experiment with natural color extraction for watercolor painting in interior architecture as follows:




4.1 Study on natural color extraction methods

Based on studies of natural color extraction, two primary methods are used: (1) water or solution extraction and (2) dry extraction. Water or solution extraction involves two methods: (1) boiling natural materials with water or (2) crushing them and then mixing them with water. Dry extraction is another method of pigment extraction, which includes three techniques: (1) drying, (2) salt adsorption, and (3) salt precipitation. Studies have shown that the most widely used method for color extraction is boiling with water or a solution, as it yields specific pigments from natural materials.

4.2 Experiment with natural color extraction for watercolor painting in interior architecture

This research is an experimental research that experiments with the extraction of color from marigolds by using marigolds for hot extraction by boiling. With 3 methods as follows: 1) From whole marigolds, 2) From fine marigolds, and 3) From only yellow petals, boil for 30 minutes. The details are as follows:

Table 4. Comparison of 3 methods of color extraction from marigolds

Extract Paint from Marigolds with Boiling Water and Paint on Paper	Method 1 (Whole Petals)	Method 2 (Petals that Have Been Pounded)	Method 3 (Only Yellow Petals)
Colored water obtained by boiling 30 minutes Ratio 1:4; boil at 140 degrees Celsius.			
	The resulting color is clear yellow.	The resulting water color is dull yellow or brownish.	The resulting water color is clear yellow.














Paint from using a paintbrush on paper.			
	It is slightly greenish-yellow.	It gets a dull yellow color.	It is bright yellow and has no other colors mixed in.

Table 5. Comparison of 3 methods of color extraction from marigolds

Method No.	Petal Treatment (g.)	Water Volume (g.)	Temperature (°C)	Extraction Time (minutes)
1	Whole petal 100	400	140	30
2	Mashed flower petals 100	400	140	30
3	Yellow petals (without green stem) 100	400	140	30

Table 6. Extraction of color from marigolds petals by boiling 3 times

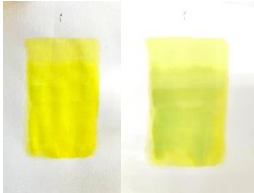
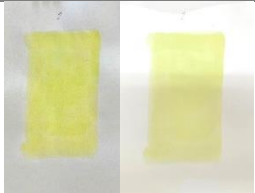
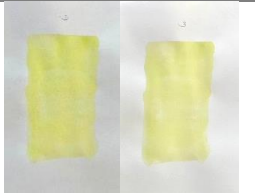






Step/Boil	1st Boil (3 Minutes)	2nd Boil (3 Minutes)	3rd Boil (3 Minutes)
1	 Cut the marigold petals so that they do not stick to the young stem parts of light green and black colors. Put in a prepared container.	Use the same set of marigolds.	Use the same set of marigolds.
2	 Put on the stove, pour clean water into a pot until it boils, then add the prepared marigold petals and boil over low heat for 3 minutes.	 Set the stove and pour clean water into the pot and the same set of marigolds. Boil for the 2nd time over low heat for 3 minutes.	 Set the stove and pour clean water into the pot and the same set of marigolds. Boil for the 3rd time over low heat for 3 minutes.
3	 Turn off the burner. Strain the colored water through a thin white cloth and put it in a container. Remove only the colored water and remove the marigold flesh.	 Turn off the burner. Strain the colored water through a thin white cloth and put it in a container. Remove only the colored water and remove the marigold flesh.	 Turn off the burner. Strain the colored water through a thin white cloth and put it in a container. Remove only the colored water and remove the marigold flesh.
4	 Get clear, yellowish-green water.	 Obtained a softer greenish-yellow water. There is a slight cloudiness.	 Get greenish-yellow water. There is more turbidity.

Tables 4 and 5 demonstrate a comparison of 3 methods of color extraction from marigolds, including: 1) Extraction of color from whole marigold petals by boiling, 2) Extraction of color from whole marigold petals by boiling, and 3) Extraction of color from only yellow petals by boiling. The ratio of marigolds to water is 1:4, and it is boiled at a temperature of 140 degrees Celsius for 30 minutes. It shows that the result of the yellowish and most vivid color is the third extraction method, which is the extraction of color from only yellow marigolds by boiling. Both the clearer yellow color and the color from the paint on the paper are brighter. However, the

extraction methods 1 and 2 will obtain the color, and the color from the drainage on the paper will be dull, dark, and slightly yellowish-greenish.

After obtaining the appropriate method of extracting color from marigolds above, the research team then conducted the next experiment. The experiment was repeated to determine the intensity of the color if it was repeated to see if the intensity would increase. A total of 3 boiling experiments were conducted, each using the same set of marigolds. Boiling time is 3 minutes at a time, as shown in Table 6.

Table 7. Comparison of marigold-colored water and calendula-colored water with alum

No Add/ Add Alum/ Boil	1st Boil	2nd Boil	3rd Boil
No alum added.	 <p>Use a brush to dip the paint water and drain it on the paper. It is bright yellow, and there are no other colors mixed in.</p>	 <p>Use a brush to dip the paint water and drain it on the paper, and the color becomes yellowish-green. The color is lighter, but when the color dries, it becomes more yellowish-green.</p>	 <p>Use a brush to dip the colored water and drain it on the paper, getting a more yellowish green color. The color is lighter, but as the color dries, it becomes more yellowish-green.</p>
Add alum.	  <p>Use a brush to dip the paint in water and paint it on the paper, which is bright yellow and has a clear intensity. Once the color has dried, it remains bright and has the same intensity.</p>	  <p>Use a brush to dip the paint in water and paint it on the paper, which is bright yellow and has a clear intensity. Once the color has dried, it remains bright and has the same intensity.</p>	  <p>Use a brush to dip the paint in water and paint it on the paper, which is bright yellow and has a clear intensity. Once the color has dried, it remains bright and has the same intensity.</p>

It can be seen from Table 6 that the color of marigolds is extracted from the petals by boiling, by cutting the petals of the marigolds so that they do not stick to the young stems of light green and black. Put the container on it. The same set of marigolds is used to boil 3 times, each time boiling for 3 minutes over low heat. It was found that the color of the water obtained was greenish-yellow and clear after the first boil, the color of the water obtained was greenish-yellow and clear, the color of the water obtained was yellowish-green and became slightly cloudy from the flesh of the petals that began to rot from the boiling, and the third boil the color of the greenish-yellow water became cloudier. From the flesh of the petals that

have been boiled until they become rottener. It shows that the first boiling will give the clearest colored water, and the next boiling will be more turbid.

After obtaining the colored water from the marigolds by boiling them three times, the experiment was continued by using an airbrush to paint on paper to compare the color differences. From the study of data on the extraction of natural colors for dyeing fabrics, it was found that when the fabric is soaked in water, the paint is soaked with dissolved alum, which helps to make the color more intense. The research team then experimented with adding alum to compare the color difference between marigold-colored water and marigold-

colored water with alum color in Table 7.

From the comparison table of marigold-colored water and marigold-colored water with alum added to it, it was found that Marigold-colored water is used when dipped in colored water and then drained on paper to be yellow and yellowish-green according to the color of the water, but when it dries, it changes color to green. However, the marigold-colored water that is added to the alum water will gradually become cloudy and darker when using a brush dipped in colored water and drained on the paper. It will get a bright yellow color from the original, and when it dries, it will still be bright and dark yellow. It shows that alum helps to make the color brighter and more intense.

5. DISCUSSION

From the study and experiment of extracting natural colors from marigolds by hot extraction by boiling to develop into watercolor in interior architecture, it was found that the most effective and vivid method of extracting natural colors from marigolds is the method of extracting color from marigolds only for yellow petals without sticking to the green leaves by boiling. Boil for just 3 minutes to get the color of the bright yellow marigolds. When tested on paper, it was bright yellow and boiled only once. It should not be re-boiled, as re-boiling will make the water cloudy and the color brightness decreased and it was found that natural colors dilute over time. Observed from the experiment of using water coloring on paper. If you want the natural color of water from marigolds to become stronger and not dilute, dissolve the alum in the water; the color will immediately darken the water. And when it is poured on paper, it gets a bright yellow color with a clear intensity. When the color has dried, it remains bright and intense. Alum helps the colors to be brighter and more intense, and the color can be used as watercolor to paint on paper to create further works.

6. CONCLUSION

The experiment of extracting natural colors from marigolds by hot extraction by boiling to develop water-based paints. The objectives were 1) to study the history of natural paints, 2) to study the method of natural color extraction, and 3) to experiment with natural color extraction for watercolor painting in interior architecture. The research team started by experimenting with an extraction method to obtain the best performance of the colored water. There are 3 methods: 1) Extraction of color from whole marigold petals by boiling, 2) Extraction of color from whole marigold petals by boiling, and 3) Extraction of color from only yellow petals by boiling. It was found that method 3, extracting the color from marigolds with only yellow petals by boiling, obtained the most yellow and vivid color and the experiment on paper is bright. After that, the color intensity is tested using the best extraction method above and then boiled again to see if the intensity increases if it is repeated boiling. A total of 3 boiling experiments were conducted, each time using the same set of marigolds. Boil for 3 minutes at a time. It was found that the 1st dip gives the most clear color. The next boiling will become more turbid accordingly. It shows that it should be boiled only once. After research, it was found that alum helps the color to be brighter and more intense. Therefore, the

experiment was conducted by dissolving the alum and putting it in colored water. This makes the colors darker and brighter, and it can be used as watercolor to paint on paper to create further works.

This study demonstrates that boiling yellow marigold petals for 3 minutes produces the most vivid yellow pigments suitable for watercolor painting. The addition of alum further enhances color brightness and intensity, making it a viable alternative to synthetic dyes. These findings contribute to sustainable design practices by repurposing ritual flowers into eco-friendly artistic materials. Future research should explore the long-term stability of these pigments and their application in other artistic media.

REFERENCES

- [1] Luzardo-Ocampo, I., Ramírez-Jiménez, A.K., Yañez, J., Mojica, L., Luna-Vital, D.A. (2021). Technological applications of natural colorants in food systems: A review. *Foods*, 10(3): 634. <https://doi.org/10.3390/foods10030634>
- [2] Rodriguez-Amaya, D.B. (2016). Natural food pigments and colorants. *Current Opinion in Food Science*, 7: 20-26. <https://doi.org/10.1016/j.cofs.2015.08.004>
- [3] Wang, B.Y., Wang, S.J. (2023). Thermal conductivity and shear strength in root-reinforced silty clay: An analysis of asteraceae plants from Taihang Mountain. *International Journal of Heat and Technology*, 41(4): 869-882. <https://doi.org/10.18280/ijht.410409>
- [4] Nuriana, W., Winarni, M., Arfan, N.A., Fudholi, A. (2023). Coloring of mahogany (*Swietenia macrophylla* King.) on textiles with mordant process and fixation against fastness. *International Journal of Design & Nature and Ecodynamics*, 18(5): 1097-1102. <https://doi.org/10.18280/ijdne.180510>
- [5] Loymek, R., Runglertsri, T., Wongkrajang, C., Ongkananuwong, S. (2024). Natural color extraction: A case study of Ban Khu Bua. *Uthenthawai Journal*, 1(1): 1-11. <https://ph03.tci-thaijo.org/index.php/UthenJo/article/download/1267/2407/13780>
- [6] Simon, J.E., Decker, E.A., Ferruzzi, M.G., Giusti, M.M., Mejia, C.D., Goldschmidt, M., Talcott, S.T. (2017). Establishing standards on colors from natural sources. *Journal of Food Science*, 82(11): 2539-2553. <https://doi.org/10.1111/1750-3841.13927>
- [7] Udompramuan, C. (2020). Local dharmic paradox knowledge to contemporary visual art. *Journal of MCU Social Science Review*, 9(4): 306-321. <https://so03.tci-thaijo.org/index.php/jssr/article/view/244857>
- [8] Frey, H.P., Honey, C., König, P. (2008). What's color got to do with it? The influence of color on visual attention in different categories. *Journal of Vision*, 8(14): 6. <https://doi.org/10.1167/8.14.6>
- [9] Aguilar-Domínguez, K.S., Pinto-Elías, R., González-Serna, J.G., Magadán-Salazar, A. (2022). Image description using the relation between color and texture in retrieval task. *Traitement du Signal*, 39(1): 21-29. <https://doi.org/10.18280/ts.390103>
- [10] Kumi, R., Conway, C. M., Limayem, M., Goyal, S. (2012). Research article learning in color: How color and affect influence learning outcomes. *IEEE Transactions on Professional Communication*, 56(1): 2-15.

- <https://doi.org/10.1109/TPC.2012.2208390>
- [11] Cooksey, C. (2013). Tyrian purple: The first four thousand years. *Science Progress*, 96(2): 171-186. <https://doi.org/10.3184/003685013x13680345111425>
- [12] Mortensen, A. (2006). Carotenoids and other pigments as natural colorants. *Pure and Applied Chemistry*, 78(8): 1477-1491. <https://doi.org/10.1351/pac200678081477>
- [13] Ghosh, S., Sarkar, T., Das, A., Chakraborty, R. (2021). Micro and nanoencapsulation of natural colors: A holistic view. *Applied Biochemistry and Biotechnology*, 193: 3787-3811. <https://doi.org/10.1007/s12010-021-03631-8>
- [14] Swami, S.B., Ghgare, S.N., Swami, S.S., Shinde, K.J., Kalse, S.B., Pardeshi, I.L. (2020). Natural pigments from plant sources: A review. *The Pharma Innovation Journal*, 9(10): 566-574. <https://www.thepharmajournal.com/archives/?year=2020&vol=9&issue=10&ArticleId=5292>
- [15] Tonthongkam, K., Sreesawas, J. (2020). The study of the color from natural materials for Thai painting. In *Proceedings of the 12th NPRU National Academic Conference*. <https://publication.npru.ac.th/handle/123456789/1215>
- [16] Borshalina, T. (2015). Marketing strategy and the development of Batik Trusmi in the regency of Cirebon which used natural coloring matters. *Procedia-Social and Behavioral Sciences*, 169: 217-226. <https://doi.org/10.1016/j.sbspro.2015.01.305>
- [17] Wongkrajang, K., Surayot, P. (2017). The effect of extractions and mordants on dyeing quality and study the compound in marigold dye. *Science and Technology Nakhon Sawan Rajabhat University Journal*, 9(10): 31-44.
- [18] Saechong, K., Thamsiri, K.P. (2006). Characteristics and properties of dye powder from marigold petal. In *Academic Conference of Kasetsart University the 44th Symposium: Education, Social Sciences, Agricultural Promotion and Communication, Humanities, Agriculture, Bangkok, Thailand*, pp. 573-580. https://kukr.lib.ku.ac.th/kukr_es/BKN/search_detail/result/10066
- [19] Sangsinchai, C., Renseb, S., Chamthong, P., Kulvanitchchayanan, K., Poomkaew, S. (2022). Dye powder from butterfly pea rosella calendula and panda leaves on adsorbent. In the 4th National Research Presentation Conference “Graduate School Conference 2022 iHappiness”, Samut Songkhram, Thailand. <http://journalgrad.ssru.ac.th/index.php/miniconference/article/view/4027>
- [20] Punyacharoennon, P., Luepong, K., Sarikanon, C. (2014). Development of powder color preparation from natural dyes. *Rajamangala University of Technology Phra Nakhon, Bangkok, Thailand*. <https://core.ac.uk/reader/304990735>