



## Plant-based lake pigments extract of Gumamela (*Hibiscus-sinenses*) and butterfly pea (*Clitoria ternatea*) as natural paint: Pigment analysis using phytochemicals

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### Abstract

Pollution in the environment is a serious global concern and synthetic paints are one of the contributing elements. Paints have a substantial environmental impact since they produce volatile organic compounds (VOCs). Paint itself is not only harmful but and poses negative impacts to both environment and human health. This study aimed to formulate a plant-based paint from extracted flowers of Gumamela (*Hibiscus-sinenses*) and Butterfly pea (*Clitoria ternatea*) which is eco-friendly, and biodegradable that can serves a main source of colored pigments essential in the production of natural paints. Prior to the experimental procedure the researchers conducted a phytochemical analysis to have a comprehensive understanding of the pigments present in the selected plant samples. Essential components of the paints such as sodium carbonate ( $\text{Na}_2\text{CO}_3$ ) and aluminum potassium alum ( $\text{KAl SO}_4$ )<sub>2</sub> were added, subsequently a gum Arabic were added and serves a paint binders it acts as adhesives, holding the pigments together ensuring that mixtures stick properly to the surface being painted. Qualities of the formulated plant-based paint was then compared to two different commercial acrylic paints in the market. The results of this study found out that plant-based paints can be used as alternatives to synthetic acrylic paints and it offers greater advantages since it has less environmental and health impacts.

**Keywords:** Natural Paint; Plant-Based; Gumamela; Butterfly Pea; Lake Pigments

### 1. Introduction

Environmental pollution is one of the major issues that has been evident recently, Sobhanie et al. (2022) and one of the contributory factors of environmental pollutants are the synthetic paints. Subsequently, another study conducted by Curtis et al. (2021) mentioned that there are thousands of chemicals being used in the production of paints, these are categorized as solvents, resin, pigments, extenders, binders, and additives their study further discussed its toxic effects. Additionally, paint contains dangerous chemicals Volatile Organic Compounds (VOCs). Li (2013) described VOCs as a broad category of organic compounds that evaporate at room temperature, causing considerable air pollution and health hazards, it includes a wide spectrum of chemicals, including hydrocarbons, alcohols, and aldehydes.

The study conducted by Kralikova, et.al, (2020) discussed that paints have a significant environmental impact due to the production of volatile organic compounds (VOCs) during drying. Paint formulations often leak almost everything but the solids into the air, once in the atmosphere, VOCs contribute to the creation of ozone. When NO<sub>x</sub> and sunlight are present, VOCs combine with oxygen in the air to create ozone, the deadliest component of smog. Furthermore, Rahim (2023) articulated the health risk of coming into contact with paints particularly on its components including solvents, which can cause respiratory issues such as coughing and soreness in the chest, particularly in the cases of prolonged exposure.

Paints are now commonly used coloring compounds that are essential for improving the visibility of structures, buildings, designs, and artwork. People prefer painting their furniture, homes, and other items. In the school setting,

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paints are seen to be essential particularly prior to the opening of every school year it is use in the beautification of the school buildings and other furniture. Moreover, paints have a significant use for students, paints are used to add color and vibrant to school projects and students' artwork. Application of paints is for both protection and decoration, but people frequently overlook the negative effects paint has on the environment and their health.

Dehm et al. (2022) articulated that plant-based paints offer significant environmental benefits compared to traditional paints, they are eco-friendly, non-toxic, and biodegradable. Furthermore, plant-based paints help reduce production costs, solve waste disposal problems, and provide high-performance coatings with anti-corrosive qualities as specified by Awasthi et al. (2019). Accordingly, Russo (2022) has claimed that plant-based paints are formulated to be low in Volatile Organic Compounds (VOCs) or even VOC-free.

The study of Baniyas and Ciudad (2023) of Negros Occidental explored the extraction of natural red lake pigments analyze by fourier transform infrared spectroscopy on the following plants, achiote, alugbate, mayana, santan and teak. The study further mentioned that vibrant and natural pigments can be easily available in various plants, their study explored the potential of red pigments from plant sources as natural dyes. As mentioned by Nwuzor et al. (2023) hibiscus extract can be used as a natural colorant. Aside from hibiscus, butterfly peas with a vibrant blue pigment has a high colorant potential.

In making paint, it is also important to consider the paint binders to be used, because it keeps the pigments together so they may create a coherent layer once the paint dries. This binding process makes sure the pigments stay spread uniformly and adhere to the surface being painted. Based on the study of Padil et al. (2022) gum Arabic offers advantages it is plant-based, water-soluble, and renewable making it an environmentally friendly alternative to conventional binders.

With the limited literature and studies conducted on the potential of a plant-based pigment sources including Gumamela (*Hibiscus-sinenses*) and Butterfly pea (*Clitoria ternatea*) being use as natural paint, this research gap provides an avenue to further explore this area of study.

This study aims to determine the potential of plant-based granulized extract pigments from Gumamela (*Hibiscus-sinenses*) and Butterfly pea (*Clitoria ternatea*) with gum Arabic as paint binders in producing natural, environmentally friendly paint that can be used in artwork.

Specifically, this study aims to; a.) determine if Gumamela (*Hibiscus-sinenses*) and Butterfly pea (*Clitoria ternatea*) contains lake pigments to increase the colors of a natural paint; b.) determine the proportion of Gumamela (*Hibiscus-sinenses*) and Butterfly pea (*Clitoria ternatea*) in grams, gum Arabic in milliliter and the chemical compounds  $\text{Na}_2\text{CO}_3$  and  $\text{KAl}(\text{SO}_4)_2$  to produce plant-based paint and c.) describe the physical characteristics of the plant-based paint in terms of texture, viscosity, and number of hours it dries, d.) analysis of commercialized acrylic paint in terms of chemical content and quality.

Additionally, this study adheres to the Young-Helmholtz theory, also known as the trichromatic theory, which suggests that human eyes perceive three colors: red, blue, and green, that can produce various colors when mixed. This theory is crucial in understanding the hues found in pigmented flowers used in this research experiment.

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## 2. Materials and methods

The researchers conducted a phytochemical testing for Gumamela (*Hibiscus-sinenses*) and Butterfly pea (*Clitoria ternatea*) using the flavonoids test. Phytochemical analysis detects and measures the bioactive substances that give plants their health benefits, it is crucial to have a comprehensive analysis of the curative properties of plants. Recent research has demonstrated the antioxidant and antibacterial qualities of many plants by showcasing a range of analytical methods and phytochemical profiles.

### 2.1. Selection of pigmented plant sources

The study used two different plant sources, it utilized the use of common, local and scientific names. Plant sources were selected based on their color and known pigmented appearance (Table 1). These plants were abundant within the researchers locality and therefore used as the main component in making natural paint in this study.

**Table 1** Plant extract sources use for natural paint

| Common name   | Local name | Scientific name          | Parts of plant Extracted with red pigment   |
|---------------|------------|--------------------------|---------------------------------------------|
| Gumamela      | Gumamela   | <i>Hibiscus-sinenses</i> | Petals of the flower                        |
| Common name   | Local name | Scientific name          | Parts of plant Extracted with green pigment |
| Butterfly pea | Puke-puke  | <i>Clitoria ternatea</i> | Petals of the flower                        |

## 2.2. Phytochemical testing

Several methodical processes are included in the phytochemical testing process in order to discover and measure the bioactive chemicals in the plant samples. Understanding plants qualities and possible uses requires this approach. Since ethanol dissolves a variety of phytochemicals well, it is frequently utilized in extraction processes Madhu (2013) and Madhuri et al. (2013), with this the researcher used a 95% ethyl alcohol in preparation for the test. According to Oloya et al., (2022) utilizing different plant extracts, it is necessary to observe test participants for seven days in order to discover any indicators. The goal of delaying phytochemical testing for 7 days mostly centers on assuring correct assessment of toxicity and the stability of phytochemical ingredients in plant extracts. This length of time enables thorough monitoring of any negative effects and the detection of bioactive substances. Phytochemical screening, which determines the quantity and kind of flavonoids present in plant extracts, depends on flavonoid testing. This is especially crucial when studying plants as flavonoids may have a role in their beneficial effects Rao et al. (2016)

Collected fresh flowers samples were cut into small pieces, the researcher prepared 20 grams of gumamela (*Hibiscus-sinenses*) and 20 grams of butterfly pea (*Clitoria ternatea*) respectively. It was eventually added to a 50mL ethanol in an Erlenmeyer flask; it was covered with metallic foil and was labelled. It was then placed in a secured place for 7 days. After leaving it for 7 days, to determine pigments present in each plant extract, various phytochemical test was administered.

To screen phytochemical in a plant alcoholic, extract the following test and procedures were done by the researcher assisted by the qualified scientist; in order to conduct alkaloid testing, 2mL of the filtrate was added with 1% Hydrochloric acid (HCl) and steamed. Right after steaming the filtrate was divided and placed in test tubes. Test tube with 1mL of the solution was mixed with 5drops of Dragendorffs reagent and additional 6 drops of Mayers reagent was put for another test tube, result of test was then recorded. In order conduct a flavonoids test, 2mL of filtrate was added with 2mL concentrated HCl plus 4 strips of magnesium ribbon, reaction was then observed. Another test, the saponin was done, 5mL of the filtrate was added to 5mL distilled water it was shaken for 30 seconds and was observed. Lastly, tannin test was administered by adding 2 mL of filtrate to mL of  $\text{FeCl}_2$  the result was din observed and recorded.

## 2.3. Preparation of plant-based natural paint

Flowers of two different plants utilized in this study were collected and prepared by the researcher. After collection, the plant samples were rinsed with distilled water, petal was then put inside the blender for extraction. Pieces of the petals was then extracted using a filter paper to collect the pigments filtrate. Researcher boiled 500mL of water using a hot plate, right after the water reached the boiling point flowers were placed inside it and set for 3minutes. Essential components of the paints such as sodium carbonate ( $\text{Na}_2\text{CO}_3$ ) and aluminum potassium alum ( $\text{KAl SO}_4$ )<sub>2</sub> were added. Sodium Carbonate ( $\text{Na}_2 \text{CO}_3$ ) a water-soluble salt that is often referred to as washing soda, performs several functions in the formation of pigments, including as regulating pH and providing sodium ions Dufault (2023). Moreover, potassium aluminum sulfate ( $\text{KAl SO}_4$ )<sub>2</sub> serves as a mordant, which is essential for attaching the dye to an insoluble carrier media used for dyeing, making it suitable for producing lake pigments. Alum reacts with dye solution to form hydrated alumina, precipitating dye and rendering it insoluble, transforming it into a pigment for paint applications (Royal Society of Chemistry). Thus, the utilization of the following chemicals in making plant-based natural paints enhances pigmentation and total quality of the product.

The researcher waited 10 minutes for the mixtures to be totally dissolved. Filter the formulated residue by utilizing a filter paper and let it dry for 4 days. Drying converts the wet pigment into a fine powder, which is then mixed with various binders to make paints or inks. The powdered form allows for improved dispersion in media, which improves the application process Kebelmann (2020). Dried flower pigments was then subjected to grinding in order to powdered the colored pigments from plants.

Gum Arabic a natural gum derived from the sap of acacia plants, namely *Acacia Senegal*. It has great adhesive capabilities that assist bind pigment particles together. Paint binders act as adhesives, holding the pigments together and ensuring that they stick properly to the surface being painted, the binding process is necessary for generating a homogeneous and constant paint coating, minimizing difficulties like peeling or flaking over time Kakali (2022). The use of a natural paint binders was used in making the natural paint which has less impact to the environment since most of its components are natural.

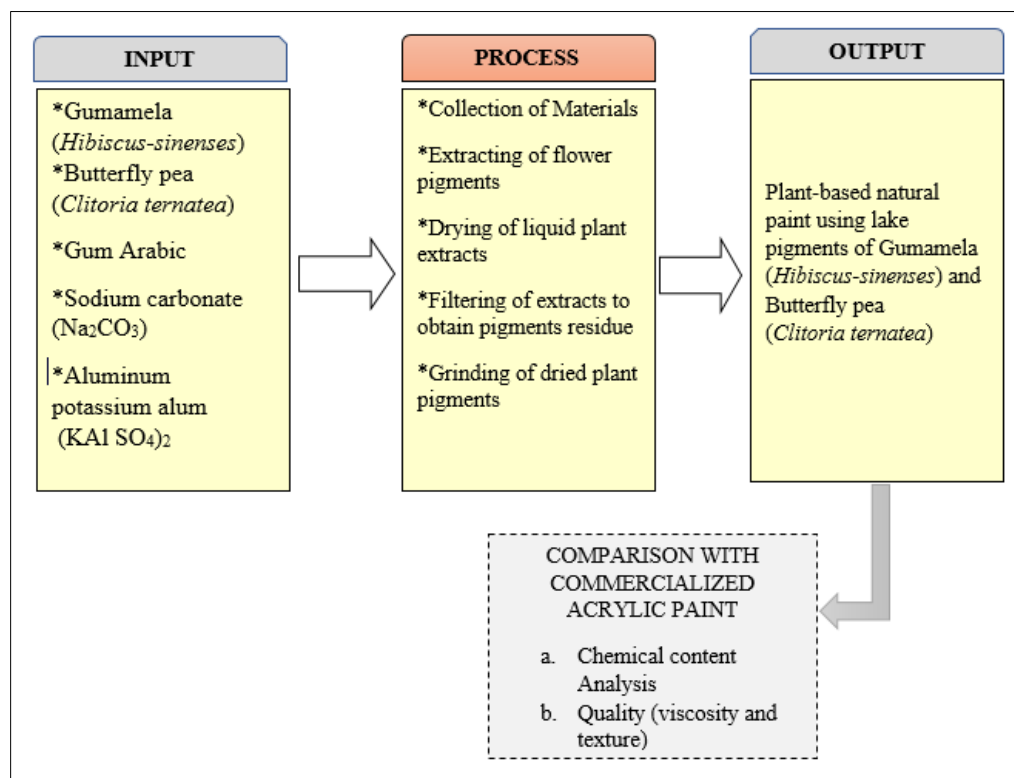


**Figure 1** Input-Process-Output Model

Figure 1 presents the Input-Process-Output Model on the production of a natural plant-based paint. The figure also show that the product of the study was compared with commercialized acrylic paints in terms of chemical contents and quality.

### 3. Results and discussion

**Table 2** Preliminary phytochemicals screening of selected flower sample for Gumamela (*Hibiscus-sinenses*)

| Phytochemicals constituents | Observation | Inference |
|-----------------------------|-------------|-----------|
| Alkaloids                   | +           | Present   |
| Flavonoids                  | +           | Present   |
| Saponin                     | -           | Absent    |
| Tannins                     | +           | Present   |

Plus (+) indicates the presence and minus (-) signifies absence

A phytochemical test was done to screen in order to identify the different pigment found in the selected plant sources. Each of these pigments contributes distinct colors and properties to paint formulations.

The above table indicates that Gumamela (*Hibiscus-sinenses*) tested for the following phytochemicals yield positive results. The phytochemical test results further indicate alkaloids, flavonoids and tannins are present in petals of

gumamela flower. Moreover, the plant sample did not produce a honeycomb structure and is therefore yield a negative result in saponin test.

**Table 3** Preliminary phytochemicals screening of selected flower sample for Butterfly tea (*Clitoria ternatea*)

| Phytochemicals constituents | Observation | Inference |
|-----------------------------|-------------|-----------|
| Alkaloids                   | +           | Present   |
| Flavonoids                  | +           | Present   |
| Saponin                     | +           | Present   |
| Tannins                     | +           | Present   |

Plus (+) indicates the presence and minus (-) signifies absence

Table 3 indicates that Butterfly tea (*Clitoria ternatea*) tested for the following phytochemicals yield a positive result. The phytochemical test results further indicate alkaloids, flavonoids and tannins are present in petals of butterfly tea flower. The following results during the phytochemical testing shows corresponding results



**Figure 2** Flavonoids test



**Figure 3** Tannins test



**Figure 4** Saponin test



**Figure 5** Alkaloids test

The following are the significant findings of the study both Gumamela (*Hibiscus-sinenses*) and Butterfly tea (*Clitoria ternatea*) yield a pink tomato color during flavonoids test; this indicates a positive result. Plant pigments known as flavonoids play a major role in the color of plants. Flavonoids have long been utilized as dyes because of their bright colors and resilience under different lighting situations, Dias., et al. (2021).

Moreover, the two plant samples produced a brownish-red precipitate during alkaloid testing the results observed that the plant samples contain alkaloids. Plant-based paint quality is kept consistent through routine testing for alkaloids, it can impact its stability and performance Hamidi., et al. (2022).

Furthermore, in this study, Gumamela (*Hibiscus-sinenses*) did not produce a honeycomb like structure in a saponin test which indicates the absence of the constituents, on the other hand Butterfly tea (*Clitoria ternatea*) created a honeycomb like structure that shows presence of saponin. Saponins in plant-based paints reduce surface tension, improves formulation mixing and stability. This property's ability to improve pigment and other component dispersion results in better paint quality and application characteristics Rai., et al. (2021). Since, saponins have antibacterial and antifungal qualities, they can prolong the life of plant-based paints by stopping the growth of microorganisms on painted surfaces, for outdoor applications where exposure to moisture and microbes is widespread, this is especially advantageous Hamidi., et al. (2022).

A blue-black precipitate was observed in both plant samples; the findings further indicate the presence of tannin. Tannins a polyphenolic substances that improve the color quality of paints made from plants, they act as mordants that help fix colors to materials and improve color fastness and brightness, [Environment Sustainable Fashion](#) (2021). With growing concerns over synthetic dyes and their environmental impact, tannins provide a natural alternative. They are biodegradable and non-toxic, making them suitable for eco-friendly paint formulations. This shift is part of a broader trend toward sustainable practices in manufacturing Leiviskä and Santos., (2022).

The results of this study were similar to the findings of Pacôme et al., (2014), hibiscus contains significant amounts of flavonoids, phenolic acids, and anthocyanin, however in this research study Gumamela (*Hibiscus-sinenses*) did not show positive results when tested for saponin constituents, similarly, another study mentioned that butterfly pea contains saponins, tannins, terpenoids, glycosides, amino acids, phenols, alkaloids, and steroids Sonali., et al., (2023).

Proportion of Gumamela (*Hibiscus-sinenses*) granulized pigment in grams, gum Arabic in milliliter and the chemical compounds  $\text{Na}_2\text{CO}_3$  and  $\text{KAl}(\text{SO}_4)_2$  in grams.

**Table 4** The amount of Gum Arabic, Gumamela (*Hibiscus-sinenses*) and chemical compounds  $\text{Na}_2\text{CO}_3$  and  $\text{KAl}(\text{SO}_4)_2$

| Set-up   | Gum Arabic | Gumamela ( <i>Hibiscus-sinenses</i> ) | Sodium carbonate | Aluminium Potassium Sulfate |
|----------|------------|---------------------------------------|------------------|-----------------------------|
| Set-up 1 | 5ml        | 10g                                   | 25g              | 15g                         |
| Set-up 2 | 10ml       | 15g                                   | 30g              | 20g                         |
| Set-up 3 | 10ml       | 15g                                   | 25g              | 15g                         |

Table 4 indicates the amount of the gum Arabic; sodium carbonate and aluminum potassium sulfate used in the production of the natural paint using pigment from Gumamela (*Hibiscus-sinenses*).

**Table 5** Proportion of Butterfly pea (*Clitoria ternatea*) granulized pigment in grams, gum Arabic in milliliter and the chemical compounds  $\text{Na}_2\text{CO}_3$  and  $\text{KAl}(\text{SO}_4)_2$  in grams

| Set-up   | Gum Arabic | Butterfly tea ( <i>Clitoria ternatea</i> ) | Sodium carbonate | Aluminum Potassium Sulfate |
|----------|------------|--------------------------------------------|------------------|----------------------------|
| Set-up 1 | 5ml        | 10g                                        | 25g              | 15g                        |
| Set-up 2 | 10ml       | 15g                                        | 30g              | 20g                        |
| Set-up 3 | 10ml       | 15g                                        | 25g              | 15g                        |

Table 5 indicates the amount of the gum Arabic; sodium carbonate and aluminum potassium sulfate used in the production of the natural paint using pigment from Butterfly tea (*Clitoria ternatea*). The researchers used different proportions of each materials pigment and. chemical compounds  $\text{Na}_2\text{CO}_3$  and  $\text{KAl}(\text{SO}_4)_2$  to attain the desired quality of the natural plant-based paint. A study by Upshall (2019) articulated that vibrant colors are achieved by increasing the amount of plant material in paint formulas, larger plant material-to-water ratio can be used to generate a stronger color, which improves the end product's color saturation.

Characterization of the physical qualities of the plant-based paint was described using texture, viscosity and the time required for the paint to totally dry in an indoor set-up.

**Table 6** Quality of a plant-based paint in comparison with synthetic paints in terms of time required too totally dry

| Time required to dry totally<br>(Minutes) |                             |                       |
|-------------------------------------------|-----------------------------|-----------------------|
| Plant-based Paint                         | HBW Synthetic acrylic paint | Kid Art acrylic paint |
| 3.0 Minutes                               | 12.5 Minutes                | 10.38 Minutes         |
| 3.0 Minutes                               | 10.0 Minutes                | 5.23 Minutes          |
| 3.0 Minutes                               | 7.78 Minutes                | 7.31 Minutes          |
| Mean=3.0 Minutes                          | Mean=10.09 Minutes          | Mean=7.64 Minutes     |

As indicated in the above table the researcher observed the quality of a plant-based paint in comparison with synthetic acrylic paints namely: HBW acrylic paint and Kid Art acrylic paint. The physical characteristics of the paint in terms of minutes it dries in a paper media was observed. With same amount of each paint, table shows that plant-based paint dries quickly, with an average time of 3 minutes for three different trials. On the other hand, synthetic paints such as HBW dry for about 10.09 minutes on average and kid art for 7.64 minutes, respectively, in an indoor set-up.

**Table 7** Comparison on the physical quality plant-based and synthetic acrylic paints

| Comparison on the Physical Qualities (Texture) |                   |                             |                                 |
|------------------------------------------------|-------------------|-----------------------------|---------------------------------|
|                                                | Plant-based Paint | HBW Synthetic acrylic paint | Kid Art Synthetic acrylic paint |
| Set-up 1                                       | Rough             | Smooth                      | Smooth                          |
| Set-up 2                                       | Smooth            | Smooth                      | Smooth                          |
| Set-up 3                                       | Smooth            | Smooth                      | Smooth                          |

The table 7 describe the physical characteristics of the plant-based paint in comparison with commercialized acrylic paint in terms of texture, table indicates that the synthetic paints such as HBW and kid art gave a smooth texture, while a plant-based paint has a rough texture on set-up 1 and the texture was smooth in set-up 2 and 3.

The physical appearance specifically the texture of the plant-based paint was compared with the synthetic acrylic paints including HBW acrylic paint and Kid Art acrylic paint.

In addition, this study indicates a comparison of the physical quality of the plant-based paint and the selected synthetic acrylic paints. Based on the results, plant-based paint had a rough texture in set-up 1, set-up 2 had a smooth texture, and set-up 3 it also had a smooth texture. On top of that HBW paint had a smooth texture within all the 3 set-ups same with Kid Art. The result of these findings is similar to the study of Hamidi et al., (2022), plant-based paints can have different textures depending on the binders and dispersion agents that are used. Compared to conventional synthetic paints, paints made with natural clays often have a thicker viscosity, which may influence application techniques.

This study further investigates the chemical contents of synthetic paint, findings include the uses acrylic polymers that serves as the primary binder in acrylic paint and have two major purposes after the paint dries, it keeps the pigment particles in place. It creates a shield that improves flexibility and durability Lewis (2021). Organic pigments are typically derived from carbon-based compounds while inorganic pigments: such as titanium dioxide (white), cadmium sulfide (yellow), and iron oxides (various colors). Synthetic paints contain Organic Volatile Compounds (VOC's), VOCs are substances that can produce hazardous gasses when they evaporate at ambient temperature. Different chemicals like formaldehyde, toluene, xylene, benzene, and acetone are typical volatile organic compounds (VOCs) included in acrylic paints. When breathed over a lengthy period of time, these substances can cause long-term health concerns like liver and kidney damage, as well as headaches, dizziness, and respiratory troubles Beck. (2020).

While main coloring agent in plant-based paints is pigment, which is derived from different plant components such fruits, flowers, and leaves, in this study only flower pigments was explored. Although paints made from plants often have reduced volatile organic compounds (VOC) content, trace quantities may still be present because of colorants or additives. Low-VOC paints, for example, are those that have fewer than 50 grams of volatile organic compounds (VOCs) per liter, whereas no-VOC paints are required to have less than 5 grams Flanagan., (2022). Regarding its binder for pigments to stick to surfaces and paint to last, binders are essential. Natural binders in plant-based paints might be anything from: Gum Arabic is a naturally occurring gum derived from acacia tree sap Chant., (2023).

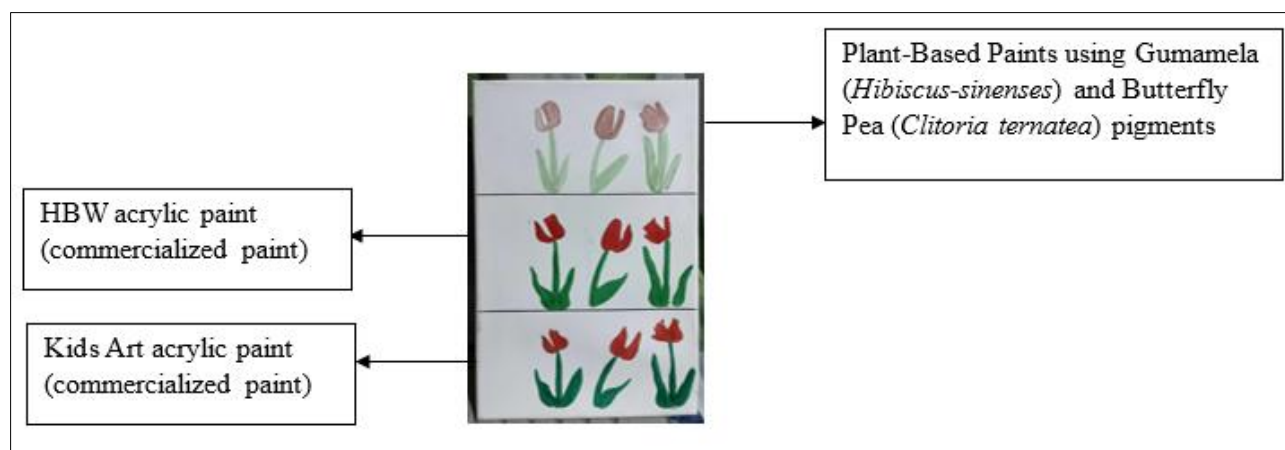


**Figure 6** Plant-based paint application on canvas in comparison with commercial paints

#### 4. Conclusion and recommendation

In the flavonoid test, the study discovered that Gumamela (*Hibiscus sinensis*) and Butterfly Tea (*Clitoria ternatea*) both produced a pink tint, signifying a successful outcome. Important plant pigments called flavonoids are renowned for their vivid hues and durability in a range of lighting situations. Furthermore, in alkaloid testing, both samples yielded a brownish-red precipitate, indicating the presence of alkaloids, which are crucial for preserving the stability and quality of paints made from plants.

Moreover, in this study gumamela (*Hibiscus sinensis*) failed the saponin test, demonstrating the lack of saponins, by failing to display a honeycomb structure. On the other hand, the honeycomb-like structure of Butterfly pea (*Clitoria ternatea*) indicated the presence of saponins. By lowering surface tension, increasing mixing and stability, and enhancing overall paint quality, saponins improve plant-based paints and improve pigment dispersion. Furthermore, by inhibiting microbial growth, their antibacterial and antifungal qualities help extend the shelf life of plant-based paints; this is especially advantageous for outdoor applications that are exposed to dampness.

Both plant samples exhibited a blue-black precipitate, indicating the presence of tannins, which are polyphenolic substances that enhance the color quality of plant-based paints. Tannins act as mordants, improving color fastness and brightness. As biodegradable and non-toxic alternatives to synthetic dyes, tannins support eco-friendly paint formulations and align with sustainable manufacturing trends. The findings are consistent with earlier research by Pacôme et al. (2014), which noted high levels of flavonoids and phenolic compounds in hibiscus, while *Gumamela* did not test positive for saponins. Conversely, Butterfly pea contains a variety of compounds, including saponins and tannins.

The researcher experimented with various proportions of pigments and chemical compounds ( $\text{Na}_2\text{CO}_3$  and  $\text{KAl}(\text{SO}_4)_2$ ) to achieve the desired quality of the plant-based paint. Increasing the amount of plant material in paint formulations leads to more vibrant colors, as a higher plant material-to-water ratio enhances color saturation in the final product. The researchers compared the drying times of three different samples with the same amount. HBW took an average of 10.09 minutes to dry, and Kid Art took 7.64 minutes, while the plant-based paint dried significantly faster, averaging 3 minutes.

In addition, this study compared the physical quality of plant-based paint with selected synthetic acrylic paints. The plant-based paint exhibited varying textures: rough in setup 1 and smooth in setups 2 and 3. In contrast, both HBW and Kid Art synthetic paints consistently had a smooth texture across all setups. These findings align with Hamidi et al.

(2022), indicating that the texture of plant-based paints can vary based on the binders and dispersion agents used. Additionally, natural clay-based paints typically have thicker viscosity, which can affect application techniques.

Moving on to the chemical contents, Synthetic paints primarily use acrylic polymers as binders, which secure pigment particles and enhance flexibility and durability. They contain organic pigments from carbon-based compounds and inorganic pigments like titanium dioxide, cadmium sulfide, and iron oxides. However, they also release volatile organic compounds (VOCs), such as formaldehyde, toluene, xylene, benzene, and acetone, which can produce hazardous gases and lead to long-term health issues, including liver and kidney damage, headaches, and respiratory problems Beck, (2020).

In contrast, plant-based paints derive their pigments from plant materials like fruits, flowers, and leaves, though this study focused only on flower pigments. Plant-based paints typically have lower VOC content, with low-VOC paints containing fewer than 50 grams per liter and no-VOC paints having less than 5 grams (Flanagan, 2022). Natural binders, such as gum Arabic from acacia tree sap, are essential for ensuring pigments adhere to surfaces and the paint lasts (Chant, 2023). Plant based paint can be formulated using plant extracts as the main source of the paint pigments, in order to create a natural paint, it also essential to use gum Arabic as paint binder which is also organic. Plant-based paint can't contribute to any environmental concerns since it does not contain hazardous chemicals, furthermore it is also safe to human health since it doesn't possess any health risks hazards. Therefore, it is safe, convenient and environmentally friendly, the researcher highly recommends to use a plant-based paint compared to synthetic one.

To further improve the study the researchers, recommend to explore 1. different extraction methods to maximize pigment yield and purity, 2. use various analytical techniques to further characterized extracted pigments, 3.try different formulation of plant-based paint to achieve optimal paint properties 4. explore other pigmented plants that has vibrant colors and 5. create a comparative analysis on the performance of synthetic and natural paints in terms of durability and relevant properties.

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## Compliance with ethical standards

### *Disclosure of conflict of interest*

No conflict of interest to be disclosed.

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