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# Ethnobotanical Study on Plants Used as Natural Dye by Handwritten *Batik* Craftsmen in Cirebon Indonesia

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**Abstract.** Cirebon Regency is one of the few Indonesian *batik* craft center which still use natural dyes in hand-written *batik* making. The natural dyes are generally extracted from plants. The kind of plants used as natural dyes source for *batik* in Cirebon Regency are not yet known. This ethnobotanical research aimed to describe the kinds of plants and their characteristics, the frequency of citation by respondents, the parts of the organs used, the sources of obtaining plants, the colors produced, usage technique, as well as the role of using natural dyes in batik to support implementation of green economy. The research approach was exploratory descriptive through observation and interview techniques for data collection. The research was carried out at Kebon Gedang Block, Ciwaringin Village, Cirebon Regency, Indonesia in September 2023. Thirty respondents were selected by purposive sampling method and subjected to the interview. The results showed there were 14 plants species from 12 families used as natural dyes. The most frequently used species were *Mangifera indica* and *Indigofera tinctoria*. The organ most widely used was the bark which comes from the purchased, and the color generally produced was brown. The most frequently coloring method used was boiling technique. This research is the first study in this area and useful for providing data and strategic potential for developing local plants as environmentally friendly natural dyes, as well as supporting efforts to use natural dyes in the *batik* industry.

**Keywords:** natural dyes; handwritten *batik*; Cirebon; ethnobotany

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## INTRODUCTION

*Batik* is one of the Indonesian textile crafts that is recognized worldwide. UNESCO has determined that *batik* is one of Indonesia's intangible cultural heritages since 2nd October 2009 (Jones, 2018). One type of *batik* is hand-written *batik*, which is a type of *batik* that uses the technique of making images on the surface of the cloth using hands and covering certain parts using wax and a *canting* tool (Purnawirawan, 2020). *Batik* is a unique cultural heritage, and each region has its own uniqueness in hand-written *batik* work, both in terms of motifs, materials, and methods of making. Creativity of *batik* art does not only deal with local culture but also it deals with the assimilation into foreign culture (Prastiwi & Hendri, 2020).

Many regions in Indonesia are known as *batik* centers, such as Pekalongan, Yogyakarta, Solo, Banten, Cimahi and Cirebon (Nuriyanto, 2022). In Cirebon Regency, precisely in the Kebon Gedang Block, there is a community of *batik* craftsmen who have different coloring techniques compared to other regions. One of the things that makes Kebon Gedang *batik* different from *batik* from other regions is that the craftsmen only produce *batik* with natural dyes from natural materials (Prawira *et al.*, 2020). Plant dyeing refers to the process of extracting pigments from plants and combining pigments with fabric through direct or mordant dyeing (Zhang *et al.*, 2018). According to Putri's research (2018), the use of natural dyes in Kebon Gedang *batik* begin with Islamic boarding school activities at the Babakan Ciwaringin Islamic Boarding School, which they made *batik* using natural dyes as a form of environmental use without causing negative impacts on the environment and this also leads to the environmental conservation awareness. This activity is also supported by the location of Ciwaringin District at an altitude of 0-150 meters above sea level which supports quite large natural resources that has great potential to be utilized,

one of which is as a natural dye.

Synthetic dyes have gradually replaced traditional plant dyes and become the main coloring material of textile dyeing because of their advantages, such as the complete chromatography, bright color, washing and sun resistance, and low price. The textile industry is classified as an industry that uses and produces hazardous and toxic waste, in which 95% of the textile industry water comes from the coloring and 5% from the rinsing process (Sirait, 2018). People's awareness towards the environmental protection, and the effects of the chemical dyes that caused irritation to the skin and their contribution toward pollution is gradually being recognized (Hu *et al.*, 2022). Synthetic dyes cause environmental pollution with the releases of heavy metals in the wastewater produced during synthetic dyeing process which are toxic to the environment. Azo dyes, the commercially important family of synthetic dye are known to be carcinogenic (Yang *et al.*, 2023). Natural dyes are recognized for their lower toxicity for both humans and the environment as well as being resilient to washing and fading (Liu *et al.*, 2014). Even so, the use of natural dyes still seems less competitive than textile dyes. In fact, Indonesia is a country that has very high natural wealth and biodiversity of natural dye plants (Agustiarini *et al.*, 2022). Many dyeing plants also have a certain medicinal and healthcare functions, which are adding to its therapeutic, economic and promotion value (Prabhu & Bhute, 2012).

Therefore, the presence of domestic craft products that use natural dyes must continue to be encouraged. However, unfortunately, until now there has been no research that has collected data and documented in detail the various plant species for natural dyes in Kebon Gedang Block. This traditional knowledge is documented only to a limited extend and is in danger of being lost due to social changes within the communities, such as dislocation, westernization, and the death of the elders with this knowledge (Malini *et al.*, 2017). In fact, this documentation needs to be carried out as important data for the development of the natural dyed *batik* industry in Cirebon Regency and in various other places, considering that the concept of sustainability in various industries, including textiles, continues to be promoted. Ethnobotany is the scientific study of a society traditional knowledge and customs about plants and their uses in the medical, religious, and other uses (Liana *et al.*, 2017). Ethnobotany studies also can provide valuable insights into the potential for utilizing plant resources, in this case the potential of natural dye plants in Indonesia. Based on these facts, this ethnobotanical research aimed to describe the kinds of plants and their characteristics, the frequency of citation by respondents, the parts of the organs used, the sources of obtaining plants, the colors produced, usage technique, as well as the role of using natural dyes in *batik* to support implementation of green economy industry.

## METHODS

The research was carried out in the Kebon Gedang Block, Ciwaringin Village, Cirebon Regency, West Java, Indonesia in September 2023. The research aplied qualitative approach, focusing on the descriptive exploratory, that aims to describe the situation of a phenomenon. In this case the phenomenon was the plants used as source of natural dyes in the Kebon Gedang Block.

The focus of this research were to identify various species of local plants used as natural dyes, their habitats, the colors they produced, plant organs used, the natural dye extraction process from the plant organs, as well as the frequency of citations of the identified plants used as natural dyes by the people of the Kebon Gedang Block, Cirebon Regency. The subjects in this research were *batik* craftsmen in the Kebon Gedang Block, Ciwaringin, Cirebon Regency. The number of research samples used was 30 people that were selected using the purposive sampling method. The criteria that can be taken as a sample must native residents or not immigrants, men and women of 26-65 years old, hand-written *batik* craftsmen who use natural dyes, and have been working for more than 5 years. The data were collected by interview using semi-structured instrument (Table 1), direct observation, and literature study.

**Table 1.** Outline of a semi-structured interview

| Question |
|---|
| 1. Which major plant species do you use for traditional dyeing? |
| 2. What is the local name of this plant dye? |
| 3. What color dye does this plant produce? |
| 4. Which plant part (root, stem, leaf, flower, fruit, peel, seed, bark) is utilized? |
| 5. Which methods are often used to extract plant dye? |
| 6. How do you use this plant dye? |
| 7. Where can we collect this plant dye? |

The observation was done by visiting to each *batik* craftsman samples, and observed directly the process of plant natural dye application. Besides, the frequency of mentioning the name of each plant was calculated. Relative frequency of mentioning was a number of informants mentioning the use of a certain species divided by the total number informants. It was calculated using the following formula:

$$F = N/T \times 100\%$$

Where F is the mentioning frequency of each plant dye utilization, N is the number of a certain plant species mentioned by informants, and T is the total number of informants. The higher the F value, the more frequently the plant dye is utilized in the local community and the higher the potential value for development (Yang *et al.*, 2023).

**Data Analysis**

Data was analyzed in three stages, namely data reduction, data display and data verification. Data reduction is a process of selecting, abstracting data, and focusing attention that takes place continuously as long as the research is carried out. The results of data reduction are then displayed in the form of tables, graphs, and images. Finally, data was verified to draw conclusions based on valid data from the results of the two previous stages. Ethnobotanical data was descriptive analyzed. On direct observation, each plant samples were found in Kebon Gedang Block was collected. Plant identification process carried out directly in the field. Plant identification process was based on morphological characteristic of the plant (stem, leaves, flowers, fruit) and was using A Photographic Atlas for the Botany Laboratory (Rushforth *et al.*, 2016), and Encyclopedia of Tropical Plants (Fayaz, 2014).

## RESULTS AND DISCUSSION

Based on the results of interview and observation conducted with *batik* craftsmen in the Kebon Gedang Block, Ciwaringin District, Cirebon Regency, 14 plant species of 12 families used as natural dyes for handwritten *batik* were identified. Most species are tree (10 species), while the rest are shrubs. The resulting colors vary, including brown, blue, gray, green, and yellow. The brown color also varies, namely light brown, dark brown and reddish brown (Table 2). Most species used as natural dye belongs to the Combretaceae and Fabaceae families, namely 2 species each (15%), while the other families only consist of one species (7%) used as natural dyes (Figure 1).

**Table 2**. List of plant species used as natural *batik* dyes in the Kebon Gedang Block, Ciwaringin District, Cirebon Regency

| No | Scientific Name | Family | Local Name | Habit | Parts Used | Color |
|---|---|---|---|---|---|---|
| 1. | *Indigofera tinctoria* L. | Fabaceae | *Indigo* | Shrub | Leaf | Blue |
| 2. | *Psidium guajava* L. | Myrtaceae | *Jambu* | Shrub | Leaf | Grey |
| 3. | *Terminalia catappa* L. | Combretaceae | *Ketapang* | Tree | Leaf | Black |
| 4. | *Tectona grandis* L. | Verbenaceae | *Jati* | Shrub | Leaf | Brown |
| 5. | *Archidendron pauciflorum* Benth. | Mimosaceae | *Jengkol* | Tree | Rind | Light brown |
| 6. | *Nephelium lappaceum* L. | Sapindaceae | *Rambutan* | Tree | Rind | Brown |
| 7. | *Garcinia mangostana* L. | Clusiaceae | *Manggis* | Tree | Rind | Reddish brown |
| 8. | *Terminalia bellirica* Gaertn. | Combretaceae | *Jolawe* | Tree | Rind | Green |
| 9. | *Cocos nucifera* L. | Arecaceae | *Kelapa* | Tree | Rind | Light brown |
| 10. | *Mangifera indica* L. | Anacardiaceae | *Mangga* | Tree | Bark | Greenish yellow |
| 11. | *Swietenia mahagoni* Jacq. | Meliaceae | *Mahoni* | Tree | Bark | Brown |
| 12. | *Cudrania javanensis* Trecul. | Moraceae | *Tegeran* | Tree | Bark/Wood | Yellow |
| 13. | *Biancaea sappan* Tod. | Fabaceae | *Secang* | Shrub | Bark/Wood | Red |
| 14. | *Ceriops tagal* C.B.Rob. | Rhizophoraceae | *Tingi* | Tree | Bark/Wood | Dark brown. |

From 14 species, leaves part of four species were used in producing natural dyes (Figure 2), five species of the fruit skin (Figure 3), and five species of the tree bark was used (Figure 4) in extracting the natural dyes for the hand-written *batik*.

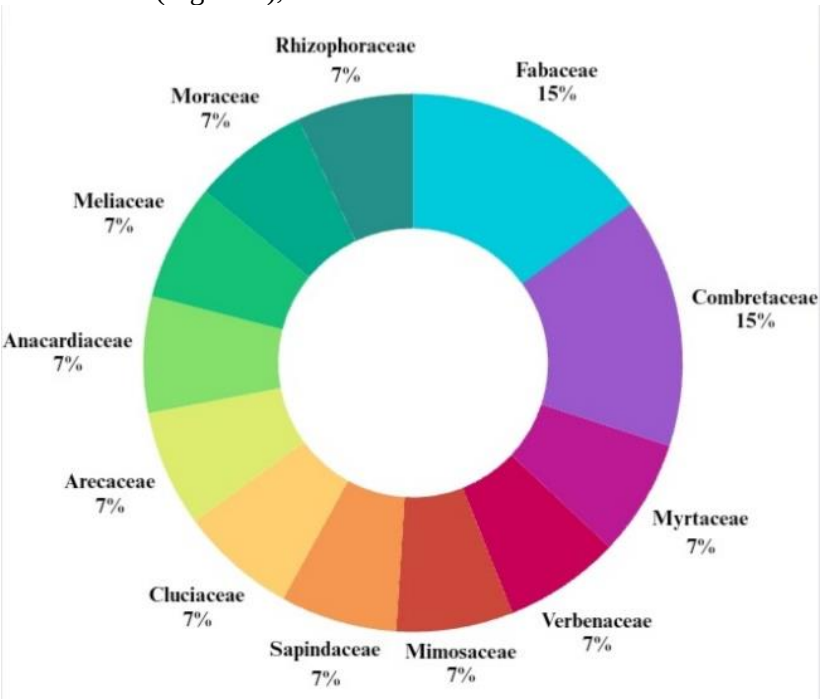


**Figure 1.** Plant families (%) used as natural dyes for hand-written *batik*

*I. tinctoria* *P. guajava* *T. catappa* *T. grandis*

**Figure 2.** The habit (top image column) and leafy part (bottom image column) of the plants used as natural dyes source

*A. pauciflorum* (Humairo *et al.*,2024) | *N. lappaceum* | *G. mangostana* | *T. bellirica* (Revathi *et al.*, 2018) | *C. nucifera*

**Figure 3.** The fruit (top image column) and rind parts (bottom image column) of the plants used as natural dyes source

*M. indica* | *S. mahagoni* | *C. javanensis* (Darsih *et al.*, 2019) | *B. sappan* (PlantNet., 2024) | *C. tagal* (Sukmarani *et al.*, 2023)

**Figure 4.** The organ characteristics (top image column) and bark parts (bottom image column) of the plants used as natural dyes source

The preference to use the natural dyes among the community was due to the fact that they are safe and friendly towards the environment, especially the aquatic environment. According to the people of the Kebon Gedang, many species grown locally can be used as a natural dye, but not all the plant species produce colors that are durable to use. These 14 species are the most common species used as natural dyes by *batik* craftsmen in the Kebon Gedang Block, Cirebon Regency. The diversity of species and families used by *batik* craftsmen in the Kebon Gedang Block is higher compared to research findings by Kaswinarni *et al.* (2019). Kaswinarni *et al.* (2019) explored the potential of natural dye plants for *batik* cloth in Ngesrepbalong Village, Kendal Regency, and reported that a total of 11 species from 7 families of plants producing natural dyes,

and the most widely used family is Fabaceae (50%). The number of species reported from this current research is higher when compared to reported work by Viviliani *et al.* (2022). Viviliani *et al.* (2022) reported that 12 species from 9 families of was used as a source for natural dye for *batik* by the people of Banyumas Regency, and the family most widely used is Fabaceae (33.3%). The differences in results can be caused by the diversity of plants in each different region, as well as the *batik* colors used in each region (Viviliani *et al.*, 2022).

Findings from the semi-structured interview that was conducted highlighted on the plant habit and most species used as a source for natural dyes were trees with a total of 10 species, while the other four plants were shrub. This is in line with previous research on natural dye plants, that the species from tree were the most widely used by the community as the natural source of dyes (Kaswinarni *et al.*, 2019). In contrast, Dalmatia *et al.* (2017) reported the number of shrub plants used in producing natural dyes is greater than trees.

The plant parts used as natural dyes for *batik* in the Kebon Gedang Block only consist of three parts, namely leaves, rind, and bark. The plant parts used for natural dyes in this present study is less when compared to other research findings. Julung *et al.* (2023) identified 6 plant parts that can be used as natural dyes in the Blonsat Village community group, namely fruit pulp, leaves, flowers, rhizomes, rind, and bark. Likewise, Berlin *et al.* (2017) identified 8 parts of plants that could be used as natural dyes in Kenaman Village, Sanggau Regency, namely leaves, flowers, fruit, bark, roots, seeds, tree sap and rhizomes. Findings from the interviews, revealed that stem bark and rind are most widely used as natural dyes source, with 5 species each (36%). Meanwhile, only 4 species (28%) produced natural dyes from the leaves part (Figure 2, 3, 4). The *batik* craftsmen in the Kebon Gedang prefer to use plant bark because the color produced was more intense so the process of repeating the coloring was faster. Meanwhile Bria *et al.* (2023), reported that the Dawan people use more leaves to produce natural dyes because it is mostly found in the environment where they live.

The colors profile produced by these plant species are very diverse. The natural dyes can be obtained by extraction treatment to remove pigments from plant parts (Rusdi *et al.*, 2020). Based on interviews with *batik* craftsmen, it was known that there were 3 species of plants that can produce brown dye, namely *T. grandis, N. lappaceum*, and *S. mahagoni*. Two species produced light brown (14%), namely *A. pauciflorum* and *C. nucifera*. Meanwhile, dark brown, reddish brown, grey, blue, black, green, yellow, greenish yellow and red each can be extracted from one species (7%). The dye colors produced depend on the method of fixative used. For example, *T. catappa* leaves will produce a black color if they are treated with *tunjung* fixative but it will be light brown if they are treated with alum, and dark brown if they are treated with lime. However, the common type of fixative used by *batik* craftsmen in the Kebon Gedang Block is alum.

However, these natural dye colors are not absolute. When a natural dye is mixed with another, it is likely to produce a different color. For example, *I. tinctoria* which produces blue color, and when it mixed with *M. indica* which produces yellow color, they will produce a new green color. Several *batik* patterns and colors produced by combining natural colors were shown in Figure 5. When three species, namely *I. tinctoria* leaves, *M. indica* and *S. mahogany* bark were combined, list of natural dyes color illustrated in Figure 5A will be obtained. Whereas the color depicted in Figure 5B will be obtained when *I. tinctoria* leaves, *M. indica* and *C. javanensis* bark were combined. When one plant was used, namely *S. mahagony* bark, the color as depicted in Figure 5C will be obtained.

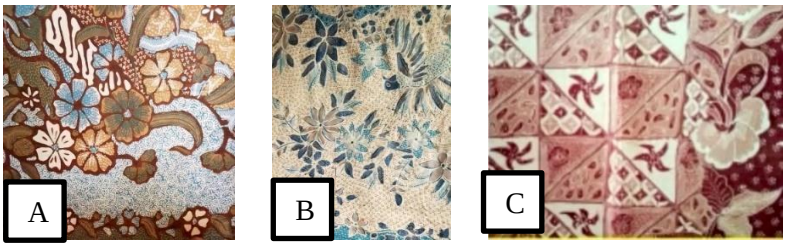


**Figure 5.** Several *Batik* patterns and colors using one or mixture natural dyes. (A) combination of *I. tinctoria* leaves, *M. indica* and *S. mahogany* bark, (B) combination of *I. tinctoria* leaves, *M. indica* and *C. javanensis* bark , and (c) *S. mahagony* bark,.

Based on the results of interviews conducted with 30 *batik* craftsmen in the Kebon Gedang Block, Cirebon Regency, the frequency of use of natural dye plants varies among one *batik* craftsman and the others. Relative frequency of citation is number of informants mentioning the use of a species divided by the total number of informants (Leonti, 2022). *I. tinctoria* and *M. indica* were widely used by *batik* craftsmen in the Kebon Gedang, with the citation frequency of 100%. All *batik* craftsmen who were the respondent in this research used these two plants as natural dyes. Meanwhile, the two species, *C. nucifera* (7%), and *B. sappan* (7%) were used the least as the source for natural dyes. These two species are rarely used because the plants are very difficult to obtain. The *batik* craftsmen must buy the parts of the plant from sellers, while the resulting color is not good.

*M. indica* is the most abundant species and commonly used as a natural dye in various regions in Indonesia (Eskak & Salma, 2020). This may be due to its presence which is easily found in the surrounding community and is usually grown in home gardens (Elfrida *et al.*, 2020). Meanwhile, *C. tagal* is usually widely used as a natural dye by communities around the coast, because this plant belongs to the mangrove group which is easily found along the coastal lines of African, Asian, and Australian (Manohar *et al.*, 2023). The Kebon Gedang Block is quite far from the beach, but there are still quite a lot of people who use it because the color results are good, whereas *C. nucifera*, even though the materials are easy to find in the environment, the color produced is not good, so that few people use it. The frequency of citations of the use of all species by the Kebon Gedang Block community as a natural dye sources is shown in Figure 6.

The origin habitats of plant species used by *batik* craftsmen in the Kebon Gedang Block can be divided into 3 (i) gardens, (ii) home yard, and (iii) purchase. The majority plants (50%) were obtained from purchased products, while 29% come from gardens and 21% from home yard (Figure 7). Plants obtained from the garden include *T. catappa, T. grandis, S. mahagoni*, and *C. nucifera*. These plant parts are directly collected by the community from the surrounding gardens and locally processed to extract the natural dyes. Meanwhile, plants species which comes from the home yard consists of *M. indica*, *P. guajava*, and *N. lappaceum*. Plants that were purchased include *I. tinctoria, A. pauciflorum, G. mangostana, T. bellirica, C. javanensis, B. sappan* and *C. tagal*. Usually they will buy from collectors who sell them in the form of plant parts. Especially for *I. tinctoria*, it is obtained from Yogyakarta and is usually in leaf powder form.

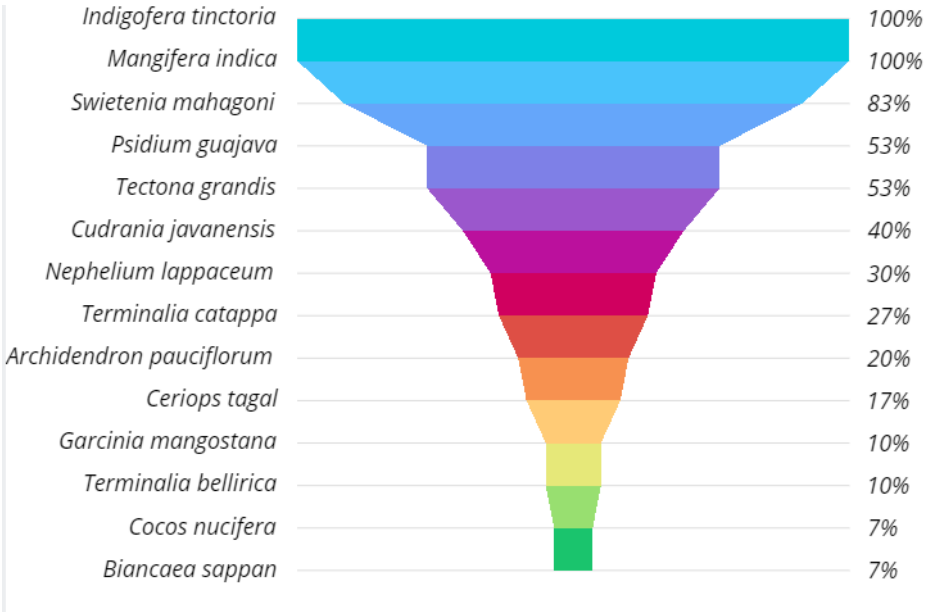


**Figure 6.** Citation frequency (%) of utilization of various plant species as natural dyes for hand-written *Batik* in the Kebon Gedang Block.

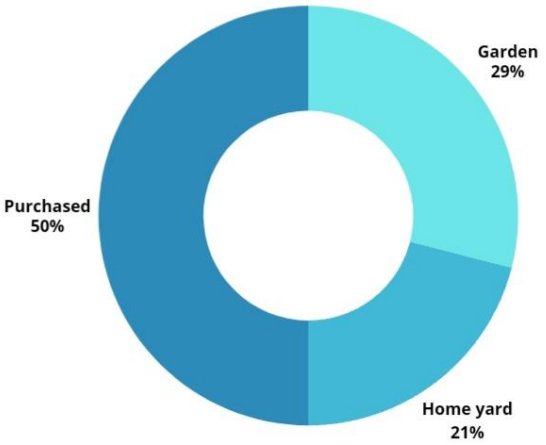


**Figure 7.** Source of plants used as natural dyes by the Kebon Gedang Community in Cirebon

The source of natural dye plants obtained in this study are slightly different compared to research by Leki *et al.* (2023) which did not find any natural dye plants obtained from purchasing. On average, the natural dye plants used by the people of Botin Leobele District were collected from forests and gardens. The community of natural dye *batik* craftsmen prefers to collect the plants from the forest or home gardens, as it does not require any costs. However, there are some plants that cannot be found in the surrounding area and have not found other alternatives, so *batik* craftsmen must buy parts of these plants.

The interviews conducted with *batik* craftsmen showed that the method for processing natural *batik* dyes in the Kebon Gedang was 100% the same. The method stage included (i) collecting the organs used as natural dyes source (leaves, rind, bark, etc.), (ii) chopping into smaller sizes, and (iii) boil them for ± 4 hours (1 kg of plant organs + 8 liters of water to make 4 liters). After the water had simmered, it was filtered, followed by cooling for 12 hours. Once cool, the extracted natural dyes solution is ready to be used. For dyes from indigo powder, every 100 grams of indigo powder was dissolved in 2 liters of water, stirred until evenly distributed, heated until homogeneous, added by 40 grams of hydro sulfite and 25 grams of soda ash, and finally mixed it with 8 liters of clean water and let it sit for 1 hour. The indigo dye solution was ready to use.

The activity of natural dyes *batik* making consists of several stages, where all output was controlled to prevent environmental pollution. So that the waste from each stage does not pollute the environment. Apart from its non-toxic nature, the average waste from each stage can also be used several times. There was also a wastewater treatment plant (WWTP) to process liquid waste from *batik* production before being discharged into the environment.

In general, the *batik* processing use natural dyes includes traditional extraction, fixation and wax removal process. Extraction is the process of boiling plant parts which will be applied to fabric as a natural dye. Meanwhile, fixation is the process of locking the color of the thread using mordan, such as lime (base), alum (low acid), or tunjung (strong acid) (Bahari *et al.*, 2020). It is possible to apply different types ad selective mordants on the textile fabrics in order to obtain diferent color or shade. Also, for any natural dye it is possible to increase the dye uptake in order to improve the color fastness behavior (Sanda & Liliana, 2021). This is because natural dyes have low color fastness (Datta *et al.*, 2023). According to Berlin *et al.* (2017), the addition of fixators in the form of alum and whiting to colored materials can produce brighter colors that last longer. Meanwhile, wax removal process is a process for removing wax by soaking the fabric in hot water (Kerlogue & Pospisilova, 2021).

The process of making *batik* using natural dyes is expected to support the government's efforts in implementing a green economy in the industry for sustainable development. The use of natural dyes has fulfilled 3 of the 5 elements of a green economy, such as minimizing waste, preserving and utilizing sustainable natural resources, and creating green jobs (Anwar *et al.*, 2023). The use of natural dyes in the *batik* industry can produce many positive benefits seen from various aspects, such as the environment, economy, and culture as shown in Figure 8.

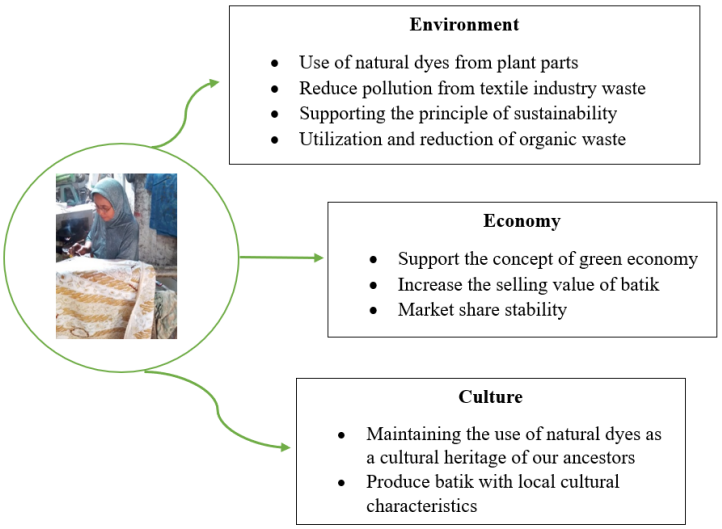


**Figure 8**. Elements of the use natural dyes in the *batik* industry viewed from environment, economy, and culture aspect

In terms of the environment, the use of natural dyes in the *batik* industry can reduce waste and pollutants. Biomass from each stage of natural dyes extraction can be reused, both in the *batik* making process and in making derivative products such as compost, biogas, and animal feed, thus supporting the 3R principle (Reduce, Reuse, and Recycle), and supporting the concept of a sustainable environment. While in terms of the economy, the use of natural dyes in *batik* can increase the selling value of the *batik* itself. Natural dye *batik* has a much higher price than textile dyes, so it has its own market share. In addition, the use of natural dyes in *batik* also supports the preservation of local culture that is distinctive and unique, and is a characteristic of the *batik* (Tkalec *et al.,* 2022)

The use of natural dyes is a manifestation of a green economy because it can improve human welfare by minimizing negative impacts on the environment (Ivlev & Ivleva, 2018). Although the potential for developing natural dyes is still very broad and continues to grow, in fact the supply of available natural dyes is still 1% of the world's demands (10,000 tons) (Senthilkumar *et al.*, 2015). The characteristics of natural dyes are indeed not the same as textile dyes and are still considered uneconomical. This is a challenge for further research to be able to develop natural dyes so that they have quality comparable to textile dyes, especially in the *batik* industry, *batik* is one of the important industries that makes a major contribution to economic growth in Indonesia (Elsahida *et al.*, 2019).

The novelty carried out in this research is the first form of documentation carried out on the surrounding plants that can be used as natural dyes in Kebon Gedang Block. In addition, this study was also able to show the species of natural dye plants that are most widely used and rarely used, as well as understanding the stages of making *batik* from natural dye plants. This research has many benefits and contribution both for science and society, including as a form of preserving traditional knowledge. For science, this research helps document traditional and ethnobotanical knowledge that may be lost along with modernization. Collected data play an important role in understanding the relationship between humans and plants in the context of their use as natural dyes. In the sociological aspects, findings from this research helps to document and promote local culture and traditions as the original cultural identity of the indigenous people of Cirebon in the use of natural dyes in *batik*, and also supports conservation activity of local plants. This research can will be beneficial in identifying and preserving natural dye plants that might be endangered, and maintaining a healthy ecosystem and supporting the livelihoods of people who depend on nature. In addition, it also contributes to innovation and technology, because it can be the basis for the application of green chemistry and material technology that supports the principles of a green economy and reducing health risks associated with synthetic dyes.

## CONCLUSION

Based on the results it can be concluded that the *batik* craftmen of Kebon Gedang Block use 14 species of plants as natural dyes in making *batik*.

The plants belong to 12 families and plant species from the Fabaceae and Combretaceae were mostly used. *M. indica* and *I. tinctoria* were the two species most widely used by the community. The plant parts that were widely used were bark and rind; and the common plant habit used as natural dyes sources were tree and shrub from purchased product. The natural dyes color produced was predominantly brown, and the processing method to produce the natural dye was through several traditional steps and must go through a boiling process. Natural dyes are non-toxic, minimize waste, and it also helps in the process of moving towards a sustainable green economy. Further research need be done includes the development of natural dyes from local plants, analysis of the chemical compounds of natural dyes and optimization of the best extraction process.

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