The Comparison Between Chemical and Natural Extraction In Textile Dyeing With Indigofera

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Abstract Indigo is categorized as a vat dyes, which is needs to pass a fermentation phase in the extraction process before it could be used as a textile dye due to its lack of fastener substances. Vat dyes are known to be the most solid dye with high endurances compared to other textile dyes according to how the colour will fade caused by acid or alkaline substances. The fermentation process of Indigofera dye could be done using chemical or natural ingredients. Sodium Hydrosulphite could be used in chemical fermentation, while Javanese brown sugar is used in natural fermentation for Indigo dye. This study uses comparative method with material experimental approach. Comparison between the use of Indigofera dye with natrium hydrosulphite fermentations and Indigofera dye with Javanese brown sugar fermentations will be analyzed. this study is purposed to find the advantages and disadvantages in both *Indigofera* dye substances made of brown sugar fermentation in the vatting process and *hydrosulfite* fermentation in the vatting process. the results of this study can be used as references in dyeing textile using indigofera for business people, craftsmen, artists, and students in developing their product designs.

Keywords Indigofera dye, natural dyes, extraction, fermentation

1. Introduction

Indigo dye is a natural based material that could be used in the making of fashion products. In Indonesia, Indigo dye used to be uses together with resist dyeing techniques like *batik* and *jumputan*. This dye called as *tarum, nila* and many other names, because it has a purplish blue colour known as *nila* in some regions of Indonesia. According to Huris Group, Indigo is a colour of a spectrum with wavelength around 450 to 420 nanometers. In Indonesia there are three species of *Indigofera, Sp* that could be used as natural dye, *Indigofera tinctoria, Indigofera arrecta,* and *Indigofera strophylantae,* but the most common one is *Indigofera tinctoria* and *Indigofera arrecta.*The making of Indigo dye is quite complicated starting from processing *Indigofera* plant to *Indigofera* paste, then to Indigo dye. For the paste to be used, vatting is needed before it was used as Indigo dye for textile. Indigo was first recovered from the water soluble glucoside of indoxyl (indi-can) present in the plants *Indigofera* and *Zsatis tinctoria*, and then the insoluble blue product was dissolved in wooden vats by a natural fermentation process later known as vatting. This was the origin of the name vat dyes. Chemically speaking, vatting is a reduction [1].

As a vat dye, the colour will not come out from *Indigofera* paste without fermentation process. Fermentation is needed to grow fastener substances on Indigo dye, because *Indigofera* doesn't have its own fastener substances that could lock the colour in fibre. A fermentation help Indigo dye to gain a fastener substances so the colour will stays on the fibre of textile, by the help of natural or chemical reductor. One of the natural reductor that could be used for natural fermentation in vatting process of *Indigofera* is Javanese brown sugar, and for chemical fermentation could use *hydrosulfite.* Beside with the help of those reductors, there are other things needed in vatting process of *Indigofera.* As a vat pigments, Indigo dye need alkaline reduction to dissolve, and it was treated to an additional step (oxidation), which causes the original insoluble pigments to be regenerated once the soluble ions have diffused within the fibre. Nevertheless, the third step, the sorption and diffusion of suitable derivatives of vat dyes into cellu-losics, parallels that of direct dyes quite closely. To make sure that the dyeing with vat dyes is successful, it's a must to have control over how and when to convert the pigmentary colours into water soluble colouring chemicals, under conditions in which they will diffuse uniformly into the fibres. There are additions to the reductor as material for fermentation such as lime and *ferrous-sulphat* [1] [2].

Hydrosulfite is white crystalline powder with a weak sulfurrous odor that stables with the absence of air. Hydrosulfite solutions have a strong reducing action and bind atmospheric oxygen. *Hydrosulfite* will react to atmospheric

oxygen many times more rapidly than its own relatively slow decomposition. To work with dissolved *hydrosulfite*, we must avoid contact with air as far as possible. In acid media, *hydrosulfite* decomposes to form mainly *sulphur dioxide*, sulphur and other sulphur-containing compounds. Alkalis have a stabilizing action on solutions of *hydrosulfite*, particularly when the solution is exposed to air. Therefore we must keep the substances in closed vessel [3].

2. Purpose of Study

In order to learn about the comparison between *Indigofera* dye made by using both *hydrosulfite* and brown sugar in the vatting process, as one of Indonesian traditional textile technique, this study is purposed to find the advantages and disadvantages in both *Indigofera* dye substances made of brown sugar fermentation in the vatting process and *hydrosulfite* fermentation in the vatting process.

3. Research Methods

This study uses comparative method with material experimental approach. Comparison between the use of Indigofera dye with natrium hydrosulphite fermentations and Indigofera dye with Javanese brown sugar fermentations will be analyzed. To gain data uses as references, author conducted literature study about Indigofera S.p, Indigofera as a dye, and vatting process.

Some experiments conducted to find the right ingredients and method to use *Indigofera* dye also the process in making the dye. The experiments inculding:

1. Making *Indigofera* dye and doing vatting process with brown sugar fermentation.
2. Making *Indigofera* dye and doing vatting process with *hydrosulfite* fermentation.
3. Dyeing fabric with *Indigofera.*

3.1. Origin of Indigo

Indigofera, Sp is a plant with about 700 species, known to have high nutrient content and production that's tolerant to abiotic stresses. These plants originated from tropical places like a region of Africa, Asia, Australia, North and South America, then they spreads to every arid regions of Africa, Asia and was brought to Indonesian by European Colonial in 1900. Additionally *Indigofera* is often used as green manure, cover crop in plantation areas, fabric dyeing and therapeutic herbs [4]. These plants have other names in some region of Indonesia, known as *tarum, nila, tom* and many other names. In Indonesia *Indigofera, Sp* is used as indigo dye or blue dye for textile, usually in the making of *kain batik* or *jumputan,* Indonesian traditional resist dyeing techniques. In Indonesia there are three species of *Indigofera, Sp* that could be used as natural dye, *Indigofera tinctoria, Indigofera arrecta,* and *Indigofera strophylantae,* but the most common one is *Indigofera tinctoria* and *Indigofera arrecta. Indigofera arrecta* is a plant originated from East Africa and South Africa, widely introduced to Laos, Vietnam, Philippine and Indonesian regions like Sumatera, Java, Sumba and Flores [4]. To make 1kg *Indigofera* dye, need around 60kg *Indigofera* plants or more. Some producer use 200kg *Indigofera* plants to make 1 kg dye. It could be turned in to *Indigofera* paste or *Indigofera* powder.

Indigofera doesn't have fastener substances in the first place, even after the plants were turned in to a paste or powder, it could not be used as a dye right away. It has to past a fermentation phase or vatting process before it could be used as a dye, to grow a fastener substance so the colour will stay on the fabric. The fermentation could be done with the help of two kind of reductors, in a chemical way could use a few grams of *hydrosulfite* and in a more natural way could use *gula Jawa* or known as Javanese brown sugar. There are slight differences between the use of *hydrosulfite* and Javanese brown sugar, starting from the process and appearances. *Hydrosulfite* solutions have a strong reducing action and bind atmospheric oxygen. *Hydrosulfite* will react to atmospheric oxygen many times more rapidly than its own relatively slow decomposition. Vatting process with *hydrosulfite* could be done in a relatively short amount of time, the oxidation needed by colour to fasten on the fibre is faster as well. Javanese brown sugar has glucose that could help the fermentation of *Indigofera* in vatting process.

3.2. Extraction

Extraction is a process to get substances from plants that could be done with two kind of method, mechanical and with solvent extraction. The extraction used to make Indigo dye is solvent extraction, to be more specific with maceration. Maceration is one of solvent extraction method, this method is started with cutting and scaling the weight of the plant, before soaking it in the water for 24 hour or more [5]. The materials and steps that researcher got for the experiment to make *Indigofera* pastes are:

1. 3kg *Indigofera* plants
2. 30 gr lime

The steps to make *Indigofera* pastes are:

1. Cut the plant and scale the weight around 3kg, and then tied it together.
2. Soak it in the water for 24 hours, if necessary put something heavy to make sure that the plants soaked and not past the surface.
3. After 24 hours, the fermentation will start, the sign is there will be blue bubbles appearing and the solution colour is green or yellowish.
4. The fermentation is done if there's no more bubbles, usually after two days it will be finished.
5. Let aeration to happen, while adding 30 gr of limes to the solution.

6. Let it be for 24 hours until the solution turns in to paste.
7. Filter the paste to divide the solution and the paste.
8. *Indigofera* paste is ready to be vatted.

After it was turned in to a paste, the paste could not be used as a dye right away. The pastes need fermentation through vatting to grow fastener substances that could lock the colour in the fibre. There are two kind of fermentation in the vatting process, with *hydrosulfite* and Javanese brown sugar. There are slight differences in the process of *Indigofera* dye vatting with *hydrosulfite* and Javanese brown sugar. Both have its own advantages and disadvantages from how it looks or what might happen in the process. Researcher outlines each of the process and looks in comparison, to divide the use of it in accordance to how it was needed. First researcher will explain about how the fermentation of Indigo with *hydrosulfite* followed with how it is with Javanese brown sugar.

3.3. Fermentation with *hydrosulfite*

Hydrosulfite or Sodium dithionite is a white crystalline powder with a weak sulfurrous odor. Although it is stable in the absence of air, it decomposes in hot water and in acid solutions. *Hydrosulfite* helps to grow fastener substances in *Indigofera* dye, to bind the color to the fibre so it will not fade. The materials needed to make a fermentation of *Indigofera* dye with *hydrosulfite* according to researcher's formula are:

1. 1 kg *Indigofera* paste
2. 8 l water
3. 20 gr *hydrosulfite* ($Na_2S_2O_4$)
4. 5 gr *ferrous sulphate* (FeSO4)
5. 200 gr lime betel

The tools needed in this process are:

1. Vessel / big jar
2. Latex gloves
3. Measure cup
4. Cups
5. Bucket
6. Digital scales
7. Spoon
8. Fabrics for filtering
9. Stove
10. Pots

The first thing to do in this experiment is to prepare the vessel for vatting, make sure the vessel have a lock so there would be no air in the vessel that could oxidates the solution during fermentation. Get the *Indigofera* dye ready in a bucket then pour 1 litter water while mixing it, then add another 7 litter of water. Add 20gr *hydrosulfite* to the solution and mix it. After that, add lime and *ferrous sulphate* and mix it, then leave it and close the jar and wait for around 6-8 minutes until the surface of the solution is yellowish or green. The sign that the solution is mixed well and can be used to dye is the colour of the solution is not blue but green or kind of yellow, that mean the solution could be used for dyeing.

There are advantages and disadvantages in vatting process with *hydrosulfite,* they are related to health and textiles. The advantages of using *hydrosulfite* as reductor for vatting process are, its only need a short amount of time for Indigo dye to be used after the vatting process, might be less than 15 minutes. Besides that, there are things to be weary like a side effect such as hard to breaths because the solution contains sulphur, and might cause skin irritation. Make sure that the experiment is not held in a small and closed space, and make sure that the hand that's used to be in contact with the solution covered with gloves.

3.4. Fermentation with Javanese Brown Sugar

For natural vatting, there are some reductors to help the fermentation such as Javanese brown sugar, sugar cane juice or fermented cassava. In this study, the use of Javanese brown sugar as a reductor for vatting process of Indigo dye will be explained. The materials needed to make a fermentation of *Indigofera* dye with Javanese brown sugar according to researcher's formula are:

1. 1 kg *Indigofera* paste
2. 8 l water
3. 1 kg Javanese Brown Sugar
4. 5 gr *ferrous sulphate* (FeSO4)
5. 200 gr lime betel

The tools needed in this process are:

1. Vessel / big jar
2. Latex gloves
3. Measure cup
4. Cups
5. Bucket
6. Digital scales
7. Spoon
8. Fabrics for filtering
9. Stove
10. Pots

For this experiment is not to different with the previous one, the first thing to do is prepare the vessel for vatting that have fastener lock, so there would be no air that could oxidates the solution during fermentation that could trigger failure. Get the *Indigofera* paste and put it in a bucket then pour 1 litter water while mixing it, then add another 7 litter of water. Prepare the pot and put 1 kg Javanese brown sugar and add another 1 litter of water, and then heat it till the sugar mixed with the water and turns to liquid. When the brown sugar solution is cooled, pour it to the *indigofera* solution and mix it together. After that, add lime and *ferrous sulphate* and mix it, then leave it and close the vessel for around 1 till 2 days until the surface of the solution is yellowish or green. The fermentation with Javanese brown sugar does need more

time due to the works of its glucose to form a fastener substances in a natural way. The advantages of using Javanese brown sugar as a reductor for vatting is, the scent is not strong enough and there's no problem with haling the scent because it didn't not contain any chemical substances that interfere with breathing. Based on researchers own experience, even if the solution made a contact with skin, it didn't not caused any kind of itches or irritation.

Table 1. Experiment result

Name	Comparison	
	Hydrosulfite	Javanese Brown Sugar
Picture		
Times	5 x 5 minutes	5 x 5 minutes
Colour	1. Solid 2. Rather pale	1. Solid 2. Bright
Process	1. Short amount of time, less than 15 minutes. 2. Not very expensive 3. Instant	1. Need a sum of time, 2 x 24 hours. 2. More expensive 3. complicated
Effect	1. Hard to breath 2. Irritation 3. Strong scent	1. Not interfere with breathing 2. Small risk of irritation 3. The scent is rather sweet.

According to the result from the experiment that has been done, each of the experiment of *Indigofera* has its own advantage and deficiency depending on the usage of it. For the vatting process using brown sugar's fermentation, the advantage lies within the value of the product and materials. The product made with this kind of dyeing, using all natural based material could give a distinctive fitures and could be known as organic product, sustainable product, ecofriendly product and some other type of specific product that has its own customer or its own niche market. The value of the product from all of the fiture could higher the price of the product. The deficiency of the product made with *Indigofera* that was fermented with brown sugar are, the cost of the production will be rather high as well, due to the good quality and rare materials used in it. Beside how high the cost that needs to be spent to create a product with *Indigofera* fermented with brown sugar, it also spent a lot of time. The duration needed for fermentating *Indigofera* with brown sugar needs a few days starting from 2 x 24 hour (the shortest amount) and according to an *Indigofera* artisan from Pekalongan, it could even take longer than 2 x 24 hour for another kind of result as this dyed could be kept for an approximately 12 days at most for the color to be on its best state. So it does take a lot of money and time to create a product with brown sugar fermentation on *Indigofera* dye.

As for the other vatting process, which is the fermentation with *hydrosulfite,* this process also has its advantages and deficiency. Making *Indigofera* dye with *hydrosulfite* could help you save more time and money compared to making *Indigofera* dye with brown sugar fermentation. The fermentation using *hydrosulfite* only needs an approximate 10 to 15 minutes. But the dye itself could not last for too long, due to the its containing *hydrosulfite* that could make the dye oxidation faster. But if the substances died, it could be brought back to life by adding another sum of *hydrosulfite* powder to the substances. *Hydrosulfite* is a corrosive substance, it also contain some dangerous traits such as carcinogenic that could cause cancer and mutagenic a mutation or deformed baby if it got consumed.

Natural dyes needs a lot of water in the process, most of the waste from natural dyes are liquid. The waste from brown sugar *fermentation* could be thrown to the ground or sewer, and it doesn't create quite a commotion. The *Indigofera* artisan in Pekalongan, threw their waste from brown sugar fermentation to the soil, and the soil remain fertile due to the calcium contained from the lime beetle and there's no dangerous substances in the liquid to begin with. As for the waste from *hydrosulfite* fermentation, it need another way of disposing it because some substances contained in it might cause danger to an organism around it. The waste from *hydrosulfite* could not be disposed in the soil because it will harm the plants and organism that lived in the land, as for disposing it to the river, sewer and the likes of it, it could be dangerous for animal and human who used the river as their water source, as the waste contains carcinogenic and mutagenic substances which might be dangerous for anyone who consume it. The artisan in Pekalongan made their own disposal to throw the waste from *hydrosulfite* fermentation so it will have to face some process before it actually flow to the river, but that doesn't guaranteed that the bad substances in it was gone.

4. Conclusion

After analyzing the result from both experiment of *Indigofera* fermentation with brown sugar and *Indigofera* fermentation with *hydrosulfite,* it can be concluded that each one of the fermentation to make *Indigofera* dye, has its own

advantages and disadvantages starting from the process in the making and the dyes resulting from it.

The complicated process and the time spent in the making of *Indigofera* dye with brown sugar fermentation could higher the value and prices of the product made by it, because the cost and time spent to make it was already categorized as expensive.Making *Indigofera* dye with *hydrosulfite* fermentation, could save more time than fermentating with brown sugar, it also save a sum of many compared to the brown sugar fermentation. But the fact that it's cheaper and faster doesn't eliminate the fact that *hydrosulfite* contains some dangerous substances that are corrosive, carcinogenic and even mutagenic, that if the waste disposal doesn't been done in the right way, it might become dangerous.

The comparison between the time spent to make the dyes are quite big. As the vatting process with *hydrosulfite* needs fermentation around 10 to 10 minutes, but the vatting process with brown sugar fermentation needs more than a day before the substance could be used to dye.

Each of the fermentation is best to use depending on the circumstances, needs and the goals that wants to be achieved.

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