An Indigo Journey:
Soul to Soul; Plant to Pigment

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Acknowledgments
Before diving into this paper, I would like to pay homage to a few individuals that have educated me throughout my indigo journey this past year. First, I would like to sincerely thank Jenelle from Neighborhood Fiber Co. in Baltimore, Maryland, for being the first to teach me how to work with various natural dyes, including madder root, weld, cochineal, myrobalan, logwood, and iron.[1] I am incredibly grateful for Rosa Chang, a fellow indigo dyer from whom I have enjoyed learning various dye and resist techniques from her Instagram and Zoom workshops.[2] At the beginning of her indigo journey, Rosa was an assistant dyer for BUAISOU when it had a short-term studio in Brooklyn, New York. BUAISOU is a sukumo-indigo dye studio based in Tokushima, Japan, and has been a fantastic visual source of information on the agricultural methods behind indigo production. Viewing the detailed documentation from their Instagram page was one of my main inspirations to grow and harvest my own Japanese indigo in my parents' backyard this past summer.[3] I cannot begin to express my thanks to Kathy Hattori and the entire team over at Botanical Colors for first sourcing all of my natural dye materials; and their incredibly educational "Feedback Friday" Zoom series that are continuously getting me through these times of isolation.[4] Many thanks to Kristin Arzt, a natural dyer, educator, gardener, and designer based in Oakland, California.[5] Kristin hosts several kinds of natural dye workshops and online classes, one of which I have had the honor to take part in about the 1-2-3 fructose indigo vat. Thanks should also go to Graham Keegan and Misa Chhan, two dyers out of Los Angeles, California who have genuinely been pushing natural dyes and shibori.[6][7] Lastly, I would like to thank my classmates from the fiber department at the Maryland Institute College of Art for being a huge creative inspiration to me and leading me to my newfound love for natural dyeing: Abbey Franklin for your incredible fabric-swatch book; documenting your non-stop exploration of natural dyes and fibers, Jailine Cano Olivias for your infinite care for plants and foods, Christian Powell for increasing my curiosity with your blue hands and psychedelic patterns with natural pigments, and Sukalp Bhatija for your stunning eye for color. These are a few of the many actors who have played a role in my learning of indigo's living blue pigment.

[1] https://neighborhoodfiberco.com/ is a small, Black-woman-owned company that sells lovely acid-dyed yarns, named after neighborhoods throughout Baltimore and Washington, D.C.
[2] https://www.instagram.com/indigosketchbook/ documents Rosa's journey of indigo and natural dyes.
[3] https://www.instagram.com/buaisou_i/ is truly a gem of visual reference.
[4] https://botanicalcolors.com/ is located out of Seattle, Washington.
[5] https://www.instagram.com/scramblesquilts/ also sells amazing natural dye kits on her website.
[6] https://www.instagram.com/yesgraham/ special thanks to Graham for selling me my first indigo seeds.
[7] https://www.instagram.com/misachhan/ produces some seriously stunning natural-dyed garments.

Introduction

My first experience with indigo pigment was a little unorthodox, but in the spring of 2020, I interned at Neighborhood Fiber Co. in Baltimore, Maryland as a studio dye assistant. During my time there, I learned how to make a pre-reduced, or rather synthetic, indigo vat using soda ash to up the pH, thiox as the reducing agent, and Jacquard pre-reduced indigo crystals. Watching the beautiful color shift from neon-green to a deep blue was literally magic to my eyes. Over-dyeing all my white and grey clothing pieces, as well as fabric swatches, instantly became a core element of my senior thesis. I could not get enough of the color-shifting, but little did I know that I was producing synthetic dye that is chemically fabricated from petroleum byproducts and commercially re-branded as "pre-reduced."

Unfortunately, my senior thesis was cut short due to the start of the COVID-19 pandemic, resulting in an unexpected move out from Baltimore and loss of access to the campus dye kitchen. To deal with this, I switched my entire studio practice to natural dyes, which led to the start of my real indigo journey. In this paper I will describe the three primary indigo-bearing plants around the world, their medicinal properties and practices, how they are grown and harvested, the chemical transformation of pigment to dyestuff, and the elements involved in making an indigo vat. With that said, I will maintain a focus on my studio and garden practice of the Japanese indigo species and the 1-2-3 fructose method for indigo vat production.

Three Primary Indigo Species

Much of the geographic information on these plants comes from Rosa Chang's "Indigo Shade Map," a term coined by Rosa in 2016 and developed further in 2020. This incredible resource is an interactive infographic map that pinpoints where these indigo species grow globally, giving essential information about the plant's existence in that location.[8]

Even though there are many variations and substrains of plants containing indican, or the chemical precursor of indigo dye, there are three primary species with distinctive formal traits and high pigment production. Some notable indigo producing species not covered in this paper include *Indigofera suffruticosa* from the Americas, *Indigofera bracteolata* from West Africa, *Marsdenia tinctoria* from Southeast Asia, *Mercurialis leiocarpa* from Japan, and *Strobilanthes cusia* from Okinawa.[9] Each species that contains indican has its distinctive physical characteristics and methods of pigment extraction. The indigo dye's chemical makeup is the same for all, but the potency of the pigment extracted may vary depending on the species itself and how healthy the plant is for producing pigment.

The first and most widely utilized indigo-bearing species is *Indigofera tinctoria*, also known as African or tropical indigo. It is a perennial plant that thrives in most tropical and subtropical regions of the world. It is a shrub or subshrub of the pea family with a maximum height of around six and a half feet. Native to India but found in Egypt and Africa, with merchants trading indigo and dye technology from India to Southeast Asia, then through the Middle East into parts of Africa, including Madagascar, and later to the Americas.[10] The genus *Indigofera*, i.e., indigo bearer, was named by Carl Linnaeus (1701-78) while founding the modern botanical classification. Many dyers thought that species within this genus produced the

[8] https://www.indigoshademap.org/ although this map does not account for all dyers and farmers, it covers some of the most well-known indigo plant cultivation locations within each continent.
[9] Marshall, John, *Singing the Blue: Soulful Dyeing for All Eternity* (Saint Titus Press, 2018) 11-12.
[10] Balfour-Paul, Jenny , *Indigo: Egyptian Mummies to Blue Jeans* (London: The British Museum Press, 2011), 91.

most dyestuff in inter-continental exchange. However, of the almost 800 species that make up the *Indigofera* genus, only a handful of these plants contain high indican levels. Distinctive physical traits of *Indigofera tinctoria* are its pinnate leaves and cone-shaped grouping of pink flowers that sprout towards the end of the growing season.[11] Bangladeshi social enterprise Living Blue farms *Indigofera tinctoria,* calling it more than just a natural dyestuff.[12] It is a legume that enriches the soil with nitrogen and only requires monsoon rain to flourish.[13] Even though *Indigofera tinctoria* is common throughout Southeast Asia and parts of Africa, a similar-looking species is the main indigo-producing plant in West Africa, *Lonchocarpus cyanescens*. In Yoruba, it is referred to as elu, gara in forested Guinea, and boula in Mande. Indigo dyer Gasali Adeyemo uses *Lonchocarpus cyanescens* for traditional Yoruba batik, adire, and tie-dye. This species is prevalent for its high indican content of up to 40 percent and is commonly used in this region with batik work.[14][15] One thing *Lonchocarpus cyanescens* has in common with *Indigofera tinctoria* is that young plants produce the best dye, unlike Japanese indigo, where the indican levels in the leaves significantly increase the more times you harvest the plant.

The second and least widely utilized species is *Isatis tinctoria*, or woad (often known by its French name, pastel), a biennial plant native to the Mediterranean and Western Asia, then reaching Europe in Britain by at least the Iron Age. The genus *Isatis* consists of over 50 species, with only a handful containing some dyestuff; *Isatis tinctoria* is the only one utilized commercially.[16] It is native to these regions' steppe and desert areas and is related to mustard and cabbage.[17] Many will also refer to this plant as European or false indigo due to the muted, blue-grey color it produces. Another main difference between *Isatis tinctoria* and the other two main indigo species is that only the first year harvest of woad contains the dye, making it a far less sustainable source for blue. The plant itself grows relatively short with arrow-shaped leaves in the first year, resembling rosettes of spinach leaves. During the second year, flowering spikes shoot up to almost four feet in length with large bundles of tiny yellow flowers in the branching head. Another common indigo-bearing plant in the woad family is *Isatis indigotica*. This species was common in China, known locally as sunglan or tienching, and in English as tea indigo, cabbage blue, or simply as Chinese woad. This species was identified and named by the botanist Robert Fortune in the 1840s as bearing more indigo than other woad species. Dyers sometimes preferred Chinese woad over the more popular Japanese indigo due to its ability to grow in colder environments. Another reason woad is historically known as European indigo is that it played an essential role in the medieval European woolen industry. Ultimately, woad was commercially discarded once imports of Japanese indigo proved to have far greater indigo extraction. Plus, the pigment extracted from these tropical indigo plants could be dried, transported, and mixed into high alkalinity vats to allow cellulose fibers to be dyed.[18]

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[11] Pinnate literally means "resembling a feather." in reference to leaflet arrangement or a venation pattern.
[12] Located in Northern Bangladesh, Living Blue consists of 3,000 indigo farmers, 40 processors, 15 trained dyers, 200 quilters and 35 shibori artisans. https://www.livingbluebd.com/
[13] Recker, Keith, *True Colors: World Masters of Natural Dyes and Pigments* (Thrums Books, 2019) 43.
[14] Indigo Shade Map: Osogbo, Nigeria https://viewer.mapme.com/e0b0f001-7464-4968-bc67-9dfce4a60735/location/4af9ff92-974a-4b01-85c5-8d553884dda6/details
[15] The term 'adire' refers to the indigo-dyed cloth in Yoruba; usually composed of complex batik patterns.
[16] Balfour-Paul, *Indigo: Egyptian Mummies to Blue Jeans,* 93.
[17] Marshall, *Singing the Blue: Soulful Dyeing for All Eternity*, 12.
[18] Woad dyestuff only works well with woolen fiber. (Balfour-Paul, 94)

Lastly, we have my personal favorite, the indigo species that I grew and harvested this past season, *Polygonum tinctorium* (=*Persicaria tinctoria*). Other names given to this plant include dyer's knotweed, Asian indigo or liaolan/蓼蓝 in Mandarin, nghể chàm in Vietnam, Korean indigo or jjok/쪽, and Japanese indigo or tadeai/蓼藍. But the word for the indigo pigment is Awa-ai/阿波藍.[19] Ai/藍 is the general Japanese word for indigo, and Awa/阿波 is a region of eastern Shikoku known as Tokushima, so Awa-ai refers to the indigo pigment produced in Tokushima.[20] To refer to the indigo plant itself, the Japanese word for *Polygonum tinctorium* is tadeai/蓼藍. I have briefly tried to research how this word relates to our English language. Unfortunately, I came up empty-handed with my English search engine's limitations and lack of Japanese knowledge. With that said, I am proposing a theory that 'tadeai' is what gave birth to our common-day phrase "tie-dye." Theories suggest that *Polygonum tinctorium* was introduced to Japan from Southern China sometime after the fifth century CE. It became a staple for natural dyeing in Japan both on a local scale in the countryside and on a commercial scale in Tokushima.[21] This plant's distinctive characteristics are its alternating dark green leaves that grow along a stem that varies between green and red, and its tiny pink or white flowers that bloom once they reach maturity, around three feet.

How to Grow Indigo: Polygonum tinctorium

As mentioned previously, this is a tropical indigo species that thrive during the rainy season in Japan, needing warm temperate weather, a fair amount of sunlight, and lots of water daily. These requirements mean that *Polygonum tinctorium* can be grown in my New York backyard, but only within the general growing period from April to the end of October. These dates may vary depending on the annual weather pattern where one lives, but the determining factor is that this species will die with frost. Once my seedlings were in the ground, I ended up watering them three times a day; twice in the daytime with a hose for around ten minutes and then around twenty minutes in the nighttime with the sprinklers. In addition to the water, the plants need to get the proper nutrients. I sprinkled granular plant food on the soil bed once a month and a few tablespoons of fish fertilizer once every two weeks. If the grower does not provide their indigo babies with the proper nutrients, they might be prone to sun damage and a lack of indigotin in the leaves. The flower's varying color is still something of a mystery to myself and other indigo growers, but the leaf's color is crucial. Japanese indigo leaves should look structurally healthy and have a dark blue-green undertone, indicating greater indican levels. I learned through troubleshooting my indigo babies that indican levels in the leaves are usually higher from the second harvest than the first. One way to harvest the plant is to pluck the healthy leaves off the stem once they are about three to four inches in length. A second method, and the one that I used, is to cut the plant's stems with a scythe, leaving about 15 inches of the plant left to grow back and produce more leaves quickly. (If you are interested in growing your own Japanese indigo plants next season, you can reach out to Graham Keegan or me for seeds. For a detailed breakdown of the agricultural tools and methods of planting Japanese indigo both at a backyard and commercial scale, I recommend looking at the stunning report put together by the Fibershed organization.[22])

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[19] The phrase for indigo dye in Mandarin is lanran/蓝染; literally meaning 'blue-dye.'
[20] Ai/藍 is identical to the traditional Chinese character for blue, lan/藍.
[21] Balfour-Paul, *Indigo: Egyptian Mummies to Blue Jeans,* 94.
[22] http://fibershed.org/wp-content/uploads/2018/01/indigo-planting-harvesting-nov2017.pdf

Medicinal Fresh Leaves

As previously stated, the leaves of all indigo-bearing plants hold indican or the indigo dye precursor. The leaves from these plants also have deep-rooted medicinal properties and practices around the world. Although most studies on this subject mention the uses of *Polygonum tinctorium* from Southern Asia and *Lonchocarpus cyanescens* from West Africa, a wide variety of indigo species all show similar uses of the plant's leaves. Many Chinese people have used P*olygonum tinctorium* to purify the liver and alleviate fever and pain.[23] Vietnamese medical practices praise the nghể chàm plant for its antibacterial effects against staphylococcus, pneumococcal bacteria, meningococcal disease, and even influenza. The leaves' enzymes are used in traditional medicine to treat fever, poisoning, tonsillitis, and bleeding gums.[24] Aboubakar Fofana, an indigo dyer out of Mali in West Africa, recalls his childhood when his grandmother asked him to pick fresh leaves for her natural-healing practices. This plant was *Lonchocarpus cyanescens*, a type of indigo species in West Africa commonly used as an antiseptic and anti-inflammatory. In this same narrative, young Aboubakar also remembers rubbing one of the leaves in his fingers, that sap from which surprisingly turned his fingers blue. This magical moment has stuck with the renowned dyer ever since.[25]

Fresh Leaves as a Dyestuff

Before we look into how fresh leaves can be used as a direct dyestuff, we must first examine the chemical process of indican to indigotin. The leaf's cells contain two key components: β-D-glucose, the critical enzyme for medicinal use, and indican, the precursor for the dyestuff. When Aboubakar's fingers turned blue from crushing that leaf, he witnessed the chemical reaction of the pigment. These two elements, β-D-glucose and indican, do not interact with each other until the cell walls are ruptured through pounding or blending, producing 'indoxyl.' The glucose enzyme acts as a catalyst in allowing the indican to bind with the oxygen molecules in the air. Once the oxygen combines with the indoxyl, the finished 'indigotin,' or indigo blue, is produced.[26]

Although indican in the leaves can survive in hot temperatures, the enzymes will die quickly and must be chilled continuously with ice. As a result, the whole dyeing process with fresh leaves must be speedy and efficient for the best results. Once you have gathered your freshly picked leaves, you will want to blend them up with some ice water for one minute. Second, strain out plant matter through a dampened cloth over a large bowl. You should repeat this blending and straining process with the leftover plant matter at least once. Lastly, place your already wet silk fabric into the fresh-leaf solution. Make sure to gently stir the fabric for an even dye job while adding lots of ice to keep the liquid cold. To achieve a deeper color, repeat this process up to four times with fresh batches of blended leaf solution. In-between dye baths, make sure to squeeze out your dyed fabric and lay it flat or hang it to oxidize evenly. Some other helpful tips from natural dyer John Marshall include the following:[27]

- It would be best to work with animal fibers like silk when working with fresh-leaf indigo due to the poor results with cellulose fibers.

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[23] https://www.drugs.com/npp/indigo.html

[24] http://nasol.com.vn/nguyen-lieu-moi/polygonum-tinctorium-nghe-cham-thanh-phan-cong-dung-chi-dinh-nguyen-lieu-nasol

[25] Recker, Keith, *True Colors: World Masters of Natural Dyes and Pigments* (Thrums Books, 2019) 20.

[26] Marshall, *Singing the Blue: Soulful Dyeing for All Eternity*, 16.

[27] If you are really interested in this topic, I would highly recommend getting John's book because he gives detailed recipes on different ways to dye with fresh-leaf indigo. (Marshall, 24)

- The time from blending the leaves to placing your silk fabric in the solution should be under five minutes.
- You should not soak your fabric in the dye solution for more than 15-20 minutes.
- Dry your fabric quickly by blotting with a paper towel and then hang to dry.
- For a good color, you will want 5:1 weight of fresh leaves to fibers.

Indigo Pigment Extraction and Vat Production

Despite producing some beautiful colors, fresh-leaf indigo has many drawbacks, including the small dyeing time frame and its weak results on cellulose fibers. Alternatively, many cultures have discovered ways to extract pigment from the leaves through a means of fermentation. Indigo dyer Yibi out of Naju, South Korea, gives step-by-step footage of the entire plant-to-pigment process on his Instagram page.[28]

First, you will need to gather your freshly harvested indigo plants; the leaves can still be on the stems for this process. Next, you will stuff as many of the plants as possible into a vessel; I used a standard five-gallon bucket. Fill up the container with preferably hot water, which will speed up the fermentation process. Place a heavy object or rock in the middle to fully submerge all the leaves. Next, you are going to cover the vessel and let it sit for four to five days. After the first day or two, you will notice the liquid turn an electric blue, almost blue Gatorade color. By day three or four, you will see an iridescent blue-purple sheen forming on the surface of the liquid as well as a pungent odor. At this point, your leaves should have changed from a lively green color to a stale yellow, indicating that they are ready to be removed.

Once you remove all the plant matter from the solution, you will need to add enough calcium hydroxide, also known as pickling lime, to raise the pH to 11. Once the pH is high enough, you will want to vigorously aerate the solution with either a stick, paint mixer attachment, or a sump pump. The time required for this step varies depending on the equipment used, but what you are looking for is a thick layer of blue foam. This aeration process combines oxygen with the indican and enzymes and turns the indigo pigment non-soluble. Once thoroughly stirred, the indigo pigment will settle to the vessel's bottom after about a day. Making sure not to disturb the bottom layer of pigment, carefully remove the amber liquid with a smaller container. You can dispose of the amber liquid, but make sure first to add some vinegar to neutralize the pH. You will then have a thick indigo sludge that can be strained in the same fashion as the fresh-leaf mixture.[29] After enough water has been strained out, lay the fabric with the sludge out in the sun where it can bake and fully dry. Scrape off all the dried indigo chips, granulate them with a mortar and pestle, and store the powder in an airtight container away from light.

You can now use this powdered indigo pigment for various indigo vats, but I will explain the 1-2-3 fructose vat for this paper. Invented by Michel Garcia, the fructose vat is a straightforward recipe to follow.[30] The ratios and ingredients are one part powdered indigo pigment, two parts calcium hydroxide, and three parts fructose sugar.[31] The calcium hydroxide raises the pH to around 10 or 11, necessary for dyeing both animal and plant fibers. The fructose sugar acts as the reducing agent for the indigo pigment since indigo is naturally insoluble in

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[28] https://www.instagram.com/cy180625/

[29] This indigo sludge can be jarred and stored at this stage. Many prefer fully drying the pigment into a powdered form for a longer shelf life.

[30] https://botanicalcolors.com/2013/02/09/make-an-easy-organic-indigo-vat/

[31] I have also experimented with henna powder as an alternative reducing agent by using the same ratio.

water. The reduction process is the only way one can use indigo pigment as a dyestuff. Mix all of these ingredients into a bucket with hot tap water, making sure not to introduce too much air into the vat since it will reverse the reduction process. After a day of curing, your vat should have an amber-color liquid at the top with the remaining sediment at the bottom layer and bubble indigo flower on the surface, all indicating a healthy, well-reduced vat. This amber liquid is what you will dye your fabric in. After a max of five minutes, you will slowly remove your material from the vat and observe that magical color shift from yellow to aqua-green to a rich indigo blue.

Conclusion

I am incredibly grateful to the many who educated me on this indigo journey. In this paper, we took a deep dive into the main three indigo-bearing species, the steps in growing Japanese indigo, using fresh leaves as medicine and a dyestuff, and how to extract pigment from the leaves for indigo vat production. What I find most beautiful about indigo is that it has introduced me to more cultures from around the world than anything else that I have researched. It has such a universal history to which virtually anyone can relate. Over the past few months, I have assembled "Indigo From Around The World," a YouTube playlist showcasing the agriculture and dyeing methods of indigo across various cultures and countries, including Korea, China, Japan, Vietnam, India, Nigeria, North America, and many more in the future.[32] Lastly, I would like to end this with a quote by Nara Shin in her 2015 studio visit at BUAISOU, Brooklyn, "There's no better way to appreciate the living beauty of indigo than by plunging your arms deep into the dark abyss."[33]

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