Natural Dyes

a primer for using mordant dyes on cellulose fabric

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Background

Natural dyes, or dyes made from plants (and in some instances animals/insects) are the oldest forms of dye. Up until the 19th century, when synthetic dyes came into use, all dyes came from natural sources. There are positive and negative aspects of both natural and synthetic dyes. However, with increasing interest in sustainability in the art and textile worlds, natural dyes are making a comeback for the small batch dyer.

There is a wealth of information in books and online about natural dyes, but not all of it is accurate. Though it is fun and romantic to use things like berries, spices, and flowers, many of those items are not dyes and will fade quickly. If one wishes to create ephemeral color, that is fine. However, to create beautifully dyed fiber and fabric that will be wash and light fast, it is important to use plants that have been tried and tested. Very few accurate resources exist that are based on science and practice. Those that I recommend are listed on the last page.

Any type of natural fiber can be dyed with natural dyes. Natural fibers are usually classified into two families: protein and cellulose. Protein fibers include any fiber that comes from an animal or insect, such as wool, silk, alpaca, mohair, etc. Cellulose fibers are plant fibers such as cotton, linen, hemp, rayon, etc. Different fibers require different handling. In general, cellulose fibers can all be treated the same.

This primer will focus on using mordant dyes on cellulose fabrics. For information on other fibers, visit the resources section on the last page. For information on indigo, please check out my Indigo booklet, also available at kimemquilts.com/dye. To speed through all the great information in the next few pages and just get started, skip to the cheat sheet on page 11.

L-R: Cotton dyed with weld, weld + cutch, cutch, madder + weld, madder + cutch, madder
Top - bottom: the dye plant alone, fabric dipped in indigo and then dyed, fabric dye and then dipped in indigo, fabric dyed and then treated with 2% ferrous acetate, fabric dipped in indigo and then dyed and treated with 2% ferrous acetate

Supplies

Dyes

I recommend the following dyes because they are tried and tested to be as colorfast as possible.

Cochineal

A bright pink/red from insects that live on prickly pear cactus in North and South America. Dried bugs require the use of a mortar and pestle to grind them up. Extract is easier to work with but both give good color.

Madder

Rubia tinctorum or Rubia cordifolia (known as Indian madder). The dried roots of the plants contain several dyes and give a deep red that can vary in tone and value. Dried ground roots give much better color than the extract.

Weld

Reseda luteola. Weld makes a bright, clear, light fast yellow. Dried plants and extract both provide excellent color.

Weld plant in its first year of growing

Pomegranate

The dried rinds of the pomegranate fruit are used to create a soft yellow / tan. Pomegranate is rich in tannin and when combined with iron can give lovely grays.

Cutch

Acacia catechu. Always found as a powdered extract. Gives a variety of shades of brown.

Dye Auxiliaries

Gallnut Tannin Extract

A "clear" tannin from oak galls used to pre-treat cellulose fabrics so they will accept the mordant.

Alum (Potassium Aluminum Sulfate)

A naturally occurring white mineral, commonly used as a mordant

Soda Ash (Sodium carbonate)

Sodium Acetate

Ferrous Sulfate

Used after dyeing to "sadden" colors

Equipment

Stainless steel or un-chipped enamel pots in a variety of sizes
Strainer
Plastic buckets and containers in a variety of sizes from one cup to 5 gallons
Digital gram scale
Tongs
Stirring spoons
Pot holders
pH neutral detergent (such as ecover, orvus, synthrapol, blue dawn)

Optional:
Quart size glass canning jars and a canning rack for doing small color tests
Tyvek, sharpie, sewing thread, sewing needle for making fabric labels

Safety

Most natural dyes are relatively safe to use when properly handled. However, it is important to use proper safety precautions any time dyes and chemicals are being used. Keep utensils, containers, and pots used for dyeing separate from those used for food. Wear a dust mask when working with finely powdered dyes and mordants. Use caution when lifting heavy pots of hot dye liquid. Protect skin against burns and chemical irritations.

Preparing to Dye

All mordants and dyes are measured based on the Weight of Fiber (wof) – what the fiber weighs when it is clean and dry. Weigh very clean or PFD (Prepared for Dyeing) fabric and write down the weight in grams. If your fabric is not labeled PFD or mercerized, it must be scoured first to remove any dirt, oil, or waxes from the manufacturing process and to allow the fabric to absorb the dye evenly. Once scoured and dry, weigh the fabric and record the weight in grams.

Scouring Process for Cellulose Fibers

1. Fill a stainless steel or un-chipped enamel pot with enough water so the fabric will be submerged and move freely. If you put your fabric in the water and part of it is above the surface or it is too hard to stir, add more water.
2. Add a small amount of neutral detergent, such as synthrapol or blue dawn and a tablespoon or two of soda ash.
3. Simmer for 30 - 60 minutes.
4. Rinse well. Repeat the process if the scour bath is very dark or dirty.
5. Dry the fabric and weigh it.

Mordant

A mordant is a metal salt used to bond a dye onto a fiber. Without a mordant most plant dyes will not sufficiently bond with fiber. There are just a few exceptions to this, for example: vat dyes, such as indigo, and direct dyes, such as cochineal on protein fibers. Mordants are essential for increasing light and wash fastness of most plant dyes.

Alum (potassium aluminum sulfate)

Aluminum salts have been used as mordants for natural dyes for centuries. Potassium Aluminum Sulfate is the most common and provides a clean color. It is inexpensive and safe to use. Some less expensive or "farm grade" alums can contain trances of iron, which will affect the color of the dye. Make sure you purchase potassium aluminum sulfate.

Aluminum Acetate

Aluminum acetate is the preferred mordant for cellulose (plant) fibers. It tends to develop a richer shade than regular alum. Manufactured aluminum acetate is expensive and loses its strength quickly, but a homemade version can be easily and inexpensively made by combining Potassium Aluminum Sulfate and Sodium Acetate and is often of better quality than purchased aluminum acetate. Alternatively, I use a combination of Alum and Soda Ash that I learned from Catharine Ellis. It gives excellent color and is less expensive.

Mordants

Iron (Ferrous Sulfate / Ferrous Acetate)

Ferrous sulfate is an optional mordant and is frequently used to shift the color of a dye to a darker, deeper shade, called "saddening" the color. Iron will turn yellow dyes greenish and red dyes purple. It can create very dark colors or grays when mixed with tannin.

Ferrous sulfate creates sulfuric acid, which is damaging to fibers as it accelerates the oxidative damage to fibers. Ferrous acetate is much more gentle on fibers and can be mixed easily from ferrous sulfate and sodium acetate. While ferrous sulfate creates sulfuric acid, ferrous acetate develops into acetic acid (vinegar) and is much less damaging to fibers. Ferrous sulfate/ferrous acetate is very powerful and is generally used at only 1 – 2% of the weight of fiber.

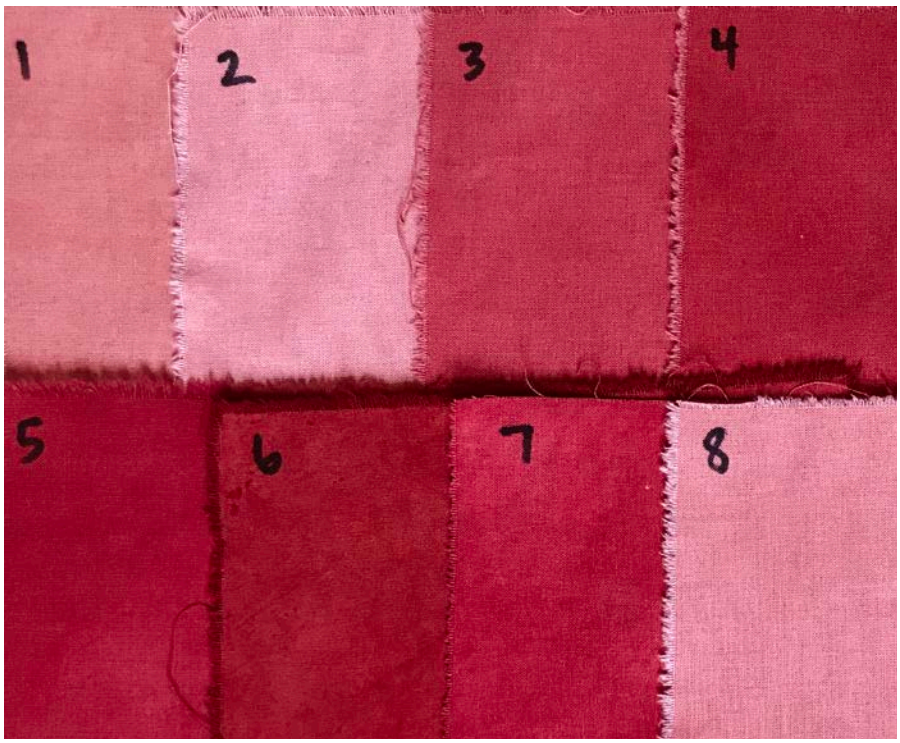
Tannin

Tannin is not a mordant, but assists the process on cellulose. Protein fibers contain an electrical charge that allows them to easily bond with alum. Cellulose fibers do not have this charge and will not combine with alum as readily. Pre-treating with tannin helps improve the bond between alum/ aluminum acetate and cellulose fibers.

There are many types of tannin available including gallnut, sumac, tara, and myrobalan. I prefer to use gallnut tannin because it is a "clear" tannin, meaning it will not affect the color. Other tannins will provide a more yellow or brown tint to the color.

Soy Milk

There is a common misconception that soy milk is a mordant. It is not. It does act like a binder to help "glue" pigments to a fiber, but that is much different than a mordant. Soy milk is used for painting earth pigments onto fiber, but will not bind a dye to a fiber the same way a mordant will. See the photo for a color comparison using soy milk as a "mordant".



Mordant comparisons on cotton dyed with 50% wof madder
1 - Soy Milk
2 - Tannin alone
3 - Alum alone
4 - Alum + Soda Ash
5 - Tannin, then Alum
6 - Tannin, then Alum + Sodium Acetate
7 - Tannin, then Alum + Soda Ash
8 - No mordant

Note that these are freshly dyed and haven't been exposed to much sunlight. Though the color of #3 and 4 look pretty similar to 5, 6, and 7, they will most likely fade significantly due to the lack of tannin as a pre-treatment. #1, 2, and 8 will also fade quickly. I will post a photo of the light fast test results on instagram @kimemquilts

Tannin + Mordant Process

Step 1 – Apply Tannin
Gallnut Tannin at 10% wof (ex. 100g of fiber requires 10g of tannin)

1. Weigh the tannin into a dry container, using a digital gram scale
2. Add the tannin to a non-reactive vessel (stainless steel, plastic, glass) and enough very hot tap water for the fabric to move freely (approx. 20:1 ratio of water to fiber)
3. Soak the cellulose fabric in the tannin bath for 1-2 hours
4. Stir occasionally. The fabric can be left in the tannin bath overnight
5. Rinse the tannin soaked fabric gently

Oak galls (r) and Gallnut Tannin

6. The fabric can be mordanted right away or it can be dried and stored for later. If saving the fabric for another day, it is helpful to label the fabric so you know it has already been treated with tannin. I hand sew a small piece of tyvek fabric into the corner of the fabric and write with sharpie what I have done. (Tyvek is available in large rolls at Home Depot or in smaller quantities on amazon and etsy)

Step 2 – Apply the Mordant
Potassium Aluminum Sulfate (alum) @ 12% wof + Soda Ash at 1.5% wof

1. Weigh the alum and soda ash separately into dry containers. Add a small amount of hot water to each container and stir well to dissolve the powders. Combine them slowly into a larger container, stirring constantly. The two mixtures will bubble significantly when combined (like vinegar and baking soda).
2. Once the bubbles have stopped, combine the mordant mixture with enough very hot tap water to cover the fiber using approximately a 20:1 water to fiber ratio.
3. If the tannin treated fabric is wet or damp, add it to the mordant solution. If the fabric is dry, get it wet first so that it can absorb the mordant evenly.
4. Allow the fabric to soak in the mordant for 1-2 hours, stirring occasionally. It can be left in the mordant solution overnight, if desired.
5. Remove the fabric, squeezing out excess mordant.
6. Rinse well. The fiber may be dyed immediately or dried for future dyeing. If you are going to dry the fabric for later use, write on the label that it has been mordanted.

Notes

Once a fabric has been mordanted, it stays mordanted.
Strong acids and bases can damage a mordant. The alkalinity of an indigo bath can dull a mordant dye and a concentrated acid (such as citric acid or lemon juice) will discharge (remove) a mordant.

Dye Process

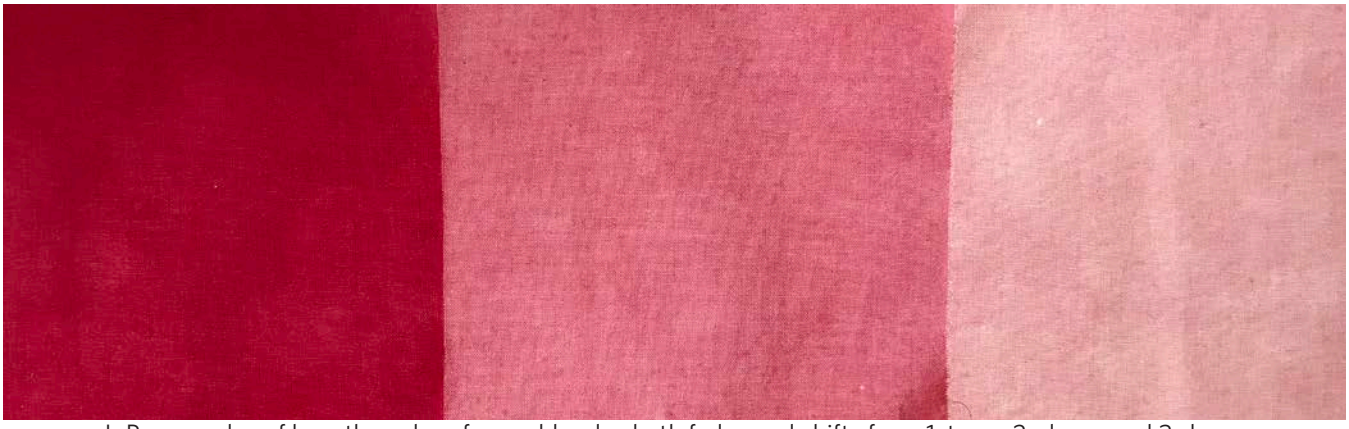
Prepare the Dye / Extraction

Cochineal: 5 - 20% wof dried insects, 1 - 2% wof extract

For dried insects, weigh the amount needed, then crush well in mortar and pestle. Cover with water and simmer 30 - 60 minutes. Strain the dye material through a fine cloth, such as cheesecloth, muslin, or silk organza and reserve the liquid in a separate container. The dye material can be covered with water and simmered again to extract more dye. The dye liquids can be kept separate and used to create different strengths of dye (the first extraction will be the strongest) or combined and used in one dye bath. It may be tempting to add the ground bugs straight to the dye bath but this will cause uneven dyeing and speckles.
For extract, weigh the amount needed, mix into a small amount of warm water and stir until smooth.

Madder: 25 - 200% wof dried roots, 5 - 10% extract

Dried, ground roots can be added directly to a dye bath. The extract should be mixed with a little hot water and stirred until smooth before being added to the bath. For roots that are not finely ground, they must chopped as small as possible and covered with water for at least 24 hours before being used to help draw out the dye. A madder bath can be saved and re-used for lighter shades. Because the madder plant contains several different dyes, successive baths may bring out different shades.



L-R, examples of how the color of a madder dye bath fades and shifts from 1st use, 2nd use, and 3rd use.

Weld: 25 - 100% wof dry plants, 100 - 300% wof fresh plants, 3 - 5% wof extract

Weld extract can be mixed with a little hot water, stirred until smooth, and then added to the dye bath. The extract tends to be very sticky and clumpy. Using boiling water to dissolve it and giving it some time seems to help. Weld plants should be chopped up and then covered with water and simmered for 30 - 60 minutes. Strain the liquid and compost the used dye material. The liquid can be added to the dye bath. You can cover the plant material with water and simmer again, but unlike cochineal and madder, weld doesn't tend to give much color in a second extraction.

Pomegranate: 20 - 40% wof ground pomegranate rind, 5 - 8% wof extract

Dried, ground rind can be added directly to a dye bath. The extract should be mixed with a little hot water and stirred until smooth before being added to the bath.

Cutch: only available as an extract, use 5 - 50% wof (the strength varies greatly)

The extract can be mixed with a little hot water, stirred until smooth, and then added to the dye bath.

Dye Process

The following instructions will work well for most natural dyes on cotton or cellulose fabric. Many books have different instructions regarding length of time in the dye bath, temperature of dye bath, etc. It is important to observe carefully what works and doesn't work and keep track of those things to find a method that fits your specific material, dye, and studio practice.

1. Add the extracted dye liquid to a stainless steel, aluminum, or un-chipped enamel pot. Add to this enough water so that the fabric can move freely and will be covered. It's ok to eyeball this.
2. Add wet, mordanted fabric. If your fabric is dry, run it under the tap to get it wet.
3. Gradually bring the temperature to a boil, as slowly as you can. Reduce to a simmer, about 195 F, then hold at that temperature one hour.
4. Fabric can be cooled in the pot overnight, or removed, rinsed, washed, and dried right away. Some dyes benefit from being left in the dye bath longer. For other dyes it makes no difference.
5. Wash fabric by rinsing well first and then washing thoroughly in hot soapy water until the water runs clear. Use a pH neutral soap such as blue dawn, ecover, or synthrapol.

canning jars for locally grown color tests

multiple dye pots on a large gas stove

marigolds on cotton, post-mordanted with 2% ferrous acetate

Post-Mordant / Color Shift

Mordant dyes can be "saddened" by being immersed in a bath of Iron - ferrous sulfate or ferrous acetate after dyeing. The fabrics will become darker and shift towards browns, purples, grays, and greens, depending on the dye. When doing color tests, it is helpful to cut a piece of dyed fabric in half and post-mordant only one piece. This will allow you to see the original color and the saddened color. Care must be taken when working with iron not to contaminate other dyes or utensils. Always measure carefully and thoroughly wash any utensils and containers that come in contact with iron before using again.

1. Add enough hot water to a non-reactive container so that your fabric can be submerged and move freely.
2. Weigh ferrous sulfate into a dry container at 1% or 2% of your wof. Only a small amount of iron is necessary to dramatically shift a color.
3. Weigh the same amount of sodium acetate into a separate dry container.
4. Combine the ferrous sulfate and sodium acetate (this makes ferrous acetate), and dissolve in the water from step 1.
5. Add wet, dyed fabric and stir well. If your fabric is dry, run it under the tap first to get it wet.
6. The color should begin to shift right away. Once you have reached the desired color (or after about 10 minutes) remove the fabric and wash well with a pH neutral soap such as blue dawn.

Record Keeping

When you first start using natural dyes it can be overwhelming. There are a lot of steps and variables and the outcomes are not always what we expect. It is helpful to keep records about what you did for two reasons. The first is so that you can recreate results that are pleasing. The second is so that you can trouble shoot when things don't go as planned. If a color comes out more pale than you expect, or more splotchy, you can go back through your notes to make sure you followed all of the steps. I recommend keeping notes on everything when you first start out, including the type of fabric, how you mordanted it, how you prepared the dye, and how long it was in the dye bath. It is also extremely helpful to label your fabric or keep a swatch in a dye notebook with your notes.

As you get more comfortable with the process, you will figure out what variables can be standardized for you. For example, I almost always use the same fabric and the same mordant process. So if I look back through my notes and don't find any mordant information, I can assume I used the Alum + Soda Ash combination outlined in this booklet. Now I only need to keep track of how much dye I used in relationship to the fiber and any special notes about the dye itself. Use the template below as a starting point for your own record keeping. A couple of pages from my dye notebook are also below for reference.

Date

Fiber / Fabric: WOF:

Scour / Wash notes:

Mordant Process:

Dye Amount:

Dye Preparation:

Dye bath notes:

Other:

In these pages I was recording how the dye looks on various fibers. They are top - bottom: cotton, linen, silk habotai, raw silk, wool gauze.

Here I was testing the wash and light-fastness of turmeric. It's such a beautiful color and smells great in the dye bath, but the light fastness tests show that it is extremely fugitive. The page on the right shows my tests on linen and silk. On the left are pages with swatches that were exposed to light for one week (right page) and one month (left page). The turmeric was almost completely gone after one month of sunlight.

Other Helpful Info

Processing Fresh Plants

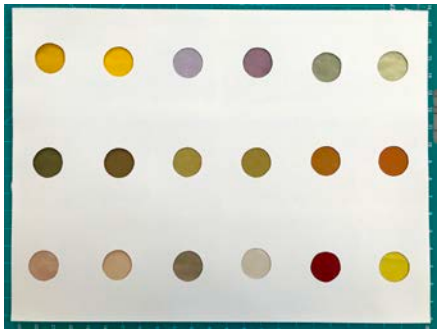
Many natural dyes are easy to grow or harvest locally. Shown here are Black Walnuts, marigolds, sumac, and parsley. Extract the dye from fresh plants the same as for Weld, above. Black Walnuts can be used at a ratio of about 1 whole walnut per 20g of fiber. All other fresh plants can be used at around 50 - 200% wof. Not all foraged options are as colorfast as the classic dyes, but they are fun to use.

Light Fastness Tests

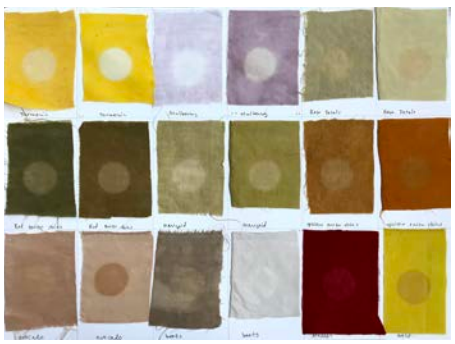
There are a lot of beautiful images on instagram and pinterest of people using berries, flowers, and herbs to "dye" fabric. While this can be a great activity for kids or to connect with your garden or environment in a new way, care should be taken to distinguish between stains and dyes. Most food items and flowers contain no actual dyes. They may create beautiful colors, but they are almost always ephemeral. In dye language, we call these fugitive colors.

If you're interested in testing out your local plants and want to find out how light fast they are, it's easy to set up light fastness experiments and fun to see how the colors change dramatically over time.

Below you can see my test set-up using food items and some things I found in my back yard. I also included swatches of madder and weld for comparison.



Left: I used double stick tape to secure a swatch of linen and silk dyed with each plant to a piece of heavy paper. Each swatch was labeled so I wouldn't forget.
Middle: I then cut holes into a second piece of heavy paper to cover up the swatches. The circles let the sunlight in so I could compare the exposed areas to the non-exposed areas.
Right: the tests were then taped up in my studio window. I exposed one set of swatches for a week and one set for a month to compare.
Right bottom: The cover was removed after one month to observe the change.



Cheat Sheet

Listen, dyeing doesn't have to be complicated. If you just want to dye something without reading all that other stuff, you came to the right place. Here's what you do:

1. Weigh your clean, dry fiber in grams. Write down the weight.

2. Soak your fabric in a solution of hot water (enough for the fabric to be stirred easily) + 10% wof tannin for at least one hour. Longer is fine but not necessary. Then rinse the fabric gently.

3. Make the mordant by combining 12% wof alum + a little hot water in a small container. In another small container combine 1.5% wof soda ash + a little hot water. Stir both solutions until everything is dissolved, then mix them together in a larger container. They will bubble a lot! Stir until the bubbles go away.

4. Combine the mordant with some more hot water and your tannin treated fabric. Let your fabric soak in there for at least an hour. Longer is fine but not necessary. Then rinse the fabric gently.

5. Make your dye bath. Extract color from plants or insects by simmering in a stainless steel, aluminum, or un-chipped enamel pot for 30 - 60 minutes. Strain and reserve the liquid. Simmer your fabric in the dye liquid for at least an hour. If using dye extracts, add them to the dye pot with some hot water and simmer the fabric for at least an hour.

6. If you want that fabric to be sad, soak it in a solution of 1% ferrous sulfate + 1% sodium acetate + hot water for about 10 minutes. If you don't want it to be sad, continue to step 7.

7. Wash your fabric well with hot water and pH neutral soap. Done!

The Natural Dyer's Manifesto

We will understand the difference between a dye and a stain.

We will honor the sun, earth, soil, plant or insect, and all the many human beings that allowed us access to these dyes by being economical and careful with our resources.

We will realize that everything fades, but we will take care to use dyes and processes that create colors that fade less quickly and to softer versions of themselves.

If we use fugitive stains, we will call them stains and we will embrace their ephemerality.

We will celebrate the now and realize that what we make is not necessarily a legacy for the future.

We will be present and mindful during the entire process.

We will ask questions, pose experiments, and continue learning through this natural dye adventure.

Resources

Supplies

Maiwa (Vancouver, Canada)
Mordants, dyes, instructions, tools
http://www.maiwa.com/home/supply/index.html

Dharma Trading Company (California) Some dyes and extracts, some mordants, lots of pfd fabric http://www.dharmatrading.com

Botanical Colors (Washington)
Dyes, mordants, information
http://botanicalcolors.com

Information

Michel Garcia (French, botanist and chemist)
Workshops and DVDs
https://naturaldyeworkshop.com/

Catharine Ellis (North Carolina)
Very informative blog and book: The Art and Science of Natural Dyes
http://blog.ellistextiles.com/

Rowland Ricketts (Indiana)
Indigo!
http://www.rickettsindigo.com/

A Verb for Keeping Warm (California)
Store, Website, Blog, + book: The Modern Natural Dyer: A Comprehensive Guide to Dyeing Silk, Wool, Linen, and Cotton at Home by Kristine Vejar
http://www.averbforkeepingwarm.com/

Other useful books

Shibori: The Inventive Art of Japanese Shaped Resist Dyeing by Yoshiko Wada, Mary Kellogg Rice, and Jane Barton

Indigo: Egyptian Mummies to Blue Jeans by Jenny Balfour-Paul

Natural Dyes by Dominique Cardon (check your library first, very expensive book)

The Art and Craft of Natural Dyeing: Traditional Recipes for Modern use by J.N. Liles

Feel free to get in touch! My contact info is below.
Tag me if you post your natural dye adventures on instagram. I would love to see what you make!

For information on indigo, please check out my indigo booklet, also available at kimemquilts.com/dye