Dyeing Cotton with Natural Dyes

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Testing dyestuffs *All photos: Alison Stattersfield*
Cotton fabric samples dyed with single dyes only

In her excellent article, published in *The Journal WSD 238* in 2011, Jenny Dean notes that many people think it is more difficult to use natural dyes on vegetable fibres than on animal ones. But she goes on to say that most traditional natural dyes will produce strong, fast colours on all natural fibres, if they are thoroughly cleaned and appropriately mordanted first. Here is an overview of how to achieve good results with cotton.

Cotton is different

The composition of cotton is different to that of wool, and this affects its affinity for dyes. Simply put, it is made of cellulose (polysaccharide consisting of large molecules of glucose) which, when immersed in water, become negatively charged. As most plant dyes are also negatively charged, the two repel each other, and so, without careful preparation, there will be poor uptake of colour.

Preparation is key

The first step is scouring. Any dirt, grease, oil, pectins or waxes must be removed to allow mordants and dyes to penetrate. As cotton is resilient to high temperatures, washing with detergent in hot or boiling water helps to strip off these impurities.

The second step is treating with tannin or a mordant (a metal salt) or both. The tannin/mordant enters the cotton fibre and combines with the dye to form an insoluble pigment. In effect, this fixes the dye in the fibre, and hence the colour, and improves wash- and lightfastness. Applying tannins and mordants can be done in cold water as, unlike wool, cotton fibres don't have scales (which require heat to open), but the fibres will need to soak for a while.

Tannic acid can be extracted by grinding up bark, wood, seedpods, nuts or leaves. It is water soluble and easily extracted in warm or hot water. The highest percentage of tannin is found in oak galls (*Quercus* sp.), the leaves of sumac (*Rhus* sp.) and tara pods (*Caesalpinia spinosa* from Peru). These tannins add little colour to the fibres and so don't affect the colours of subsequent dyeing.

The metal salt mordants most used are those of aluminium as these are considered the least toxic and produce the brightest colours: for example, potassium aluminium sulphate, often referred to as alum, found as naturally occurring crystals or extracted from minerals or rocks, but mostly industrially produced today. An organic alternative is the powdered leaves of *Symplocos*, a genus of flowering plant species, found in Asia and the Americas, that absorbs aluminium from acidic soils. But I have yet to try this. The best mordant for cellulose fibres is aluminium acetate, which can be bought as a fine powder or, because it reputably has a short shelf life, made directly from alum as needed.

The fibres are treated with tannin (Step 1), followed by the aluminium mordant (Step 2). Cotton can be mordanted without tannin, provided that a concentrated aluminium acetate solution is used. However, according to Boutrup and Ellis (2018) cellulose fibres mordanted in this way should be dried (before rinsing) and then 'dunged'. Traditionally, cow dung was used, hence the name, but chalk (calcium carbonate) also works. This ensures that the acid has been neutralised and the mordant has precipitated in the textile. Dean (2010, 2011) also uses aluminium acetate, but without dunging, and discusses this approach in her blog (Dean 2019).

Select the best dyes

All the classic dyes (e.g. cochineal, dyer's greenweed, indigo, logwood, madder and weld) are equally suitable for both animal and vegetable fibres (Dean 2011). As you would expect, dyes that are rich in tannins are also good, such as fustic, henna, myrobalan, pomegranate (all yellow) and cutch (reddish-brown), and can be applied without a mordant (so-called direct or substantive dyes). Powdered dye extracts (dye chemicals which have been extracted from natural dyestuffs) can also be used. However, it isn't always clear in dye manuals whether or how some dyes will work with cotton, and often the information presented is for wool only. But see box below for examples of some of the natural dyes that I have found to work well with cotton.

Natural dyes that work with cotton

Dyes (other than those mentioned in the text) for which I have achieved good results include alder (cones, twigs), birch (bark, chippings), bracken (leaves), broom (flowers), buckthorn (berries), carrot (tops), chamomile (flowers), *Coreopsis* (flowers), dahlia (flowers), French marigold (flowers), goldenrod (flowers), grape vine (leaves), heather (flower tips), juniper (berries), meadowsweet (flower tips), nettle (tops), oak (acorns), red and yellow onion (skins), *Rudbeckia*/black-eyed Susan (flowers), Osage orange (shavings), sappanwood (chips), walnut (husks) and yellow flag iris (roots).

Dyeing with indigo
Cotton lampshade with stitched shibori

Eco-printing
Cotton lampshade, mordanted with tannin and alum, printed with leaves dipped in iron water

Choose a method

The methods for applying natural dyes to vegetable fibres are basically the same as those for animal ones, e.g., extract the dye by simmering for up to one hour, then immerse the fibres and simmer gently for up to one hour. However, it may be necessary to use a higher percentage of dyestuff to fibres, and to leave the fibres in the dye bath for longer to allow time for the dyes to penetrate the fibres.

Dyeing without heat can be successful, whereby the fibres are left in the dye bath overnight, or longer (up to five days). Also, solar dyeing can yield good results: fibres are left with the dyestuff in glass jars in the sun for as long as you want (weeks to months). As many dyestuffs (especially flowers and leaves) will release their dyes without heat, it's possible to take this approach in winter too.

It's important to test the pH of the dye bath. This is because the chemical combination of the dye and the tannin/mordant occurs most readily in neutral or slightly alkaline conditions. So, if the pH of the dye bath is acidic, the dye may not attach to the tannin/mordant in the cotton fibre, and the acid may remove the mordant from it. Ellis (2020) recommends adding a small amount of chalk to neutralise acid when dyeing cotton with yellow dyes. Some dyes are pH sensitive, notably cochineal and lac, and the colour can be shifted by the addition of acids or alkalis to the dye bath, but Boutrup and Ellis (2018) say that acids shouldn't be used in this way when dyeing with mordanted cellulose.

Dyeing with indigo

Dyeing with indigo is different. First, the dye liquid must be alkaline and second, oxygen must be removed so that the insoluble blue indigo pigment is converted into soluble 'indigo-white', and dyeing can take place. Indigo is a great dye to use with cotton because it doesn't require a mordant and because cotton fibres are tolerant of the alkaline conditions needed.

Printing works well

Printing is the direct application of colour on fabric or yarn using various objects. As with conventional dyeing, mordants and dyes bind within the fibres, but the mordant is only required where the pattern is required, and so a paste is used. This approach works very well with cotton, because the mordant/dye can easily penetrate the fibres.

Extend your colours

Iron (ferrous sulphate or acetate) and copper (copper sulphate) can be used as post-mordants to darken or 'sadden' the colour and increase lightfastness, but iron should only be used in very small amounts as it damages fibres. Be aware that cotton that has been treated with tannin will interact with iron to form grey or black depending on the tannin concentration, and so the original colour may become obscured.

Most dye stuffs yield yellow dyes, but colours can be over-dyed to create different ones, for example, indigo can be combined with yellow dyes to create greens and with red ones to create purples. For cellulose fibres it is best to dye with indigo first, then to mordant, and finally to overdye, as the mordant-dye bond can be damaged by the high alkalinity of the indigo vat.

Exploiting the tannin/iron interaction

Of course, grey/black may be the colour that you want and so, with cotton, you can achieve this through the interaction of tannin and iron. This approach is used by many cultures for dyeing traditional fabrics, such as African mud cloth from Mali whereby cotton fabric is first treated in baths of leaves and branches, dried, and then painted with patterns using iron-rich mud.

The tannin/iron interaction is important in eco-printing too: leaves can be dipped in ferrous sulphate solution so that they print when bound tightly to damp tannin-mordanted cotton cloth and steamed. Alternatively, the cloth can be mordanted with aluminium acetate and ferrous sulphate and, in this case, it is the tannins in the leaves that will react with the mordant/iron to make the print. Or an iron blanket can be placed over the leaves so that the iron interacts with the tannin-mordanted cloth underneath and forms an outline around the leaves.

Consider fastness

In my experience, the washfastness of nearly all the natural dyes that I have tested on cotton fibres has been extremely good. However, the same is not true for lightfastness where about half the natural dyes that I have tested on cotton have faded more than wool. That said, all dyes (including synthetic ones) on all fibres will fade over time – it's just a question of how quickly this happens. Some dyes lighten, while others change colour. As tannins often deepen in colour when exposed to UV light, cotton which has been treated and or dyed with tannins may darken or turn brownish.

Printing with a mordant and dye extracts
Upcycled cotton top

Blending colours
Cotton scarf woven from a warp dyed with weld, madder, walnut and indigo

A special case

Safflower is a unique dye – its flower petals contain both yellow and red dyes. To obtain the latter, the yellow dye must be rinsed out first (and used or not), then the red dye can be extracted in an alkaline solution (washing soda) and precipitated in an acid solution (vinegar, lemon juice). The dye is suitable for cotton, linen and silk, but not wool. It's not lightfast – a property exploited for the 'red tape' used to tie legal documents in England until the twentieth century. The idea being that, if untied, it would be impossible to retie without evidence of tampering, because of the difference in fading between the covered and exposed fabric.

Final thoughts

Until 1856, all dyestuffs were of animal or vegetable origin. But, following the discovery of synthetic dyes, natural dyeing, along with the dyers' knowledge and their recipes, largely disappeared. The revival of interest has tended to focus on the less-complicated processes required for wool. And yet, as evidenced by museum specimens, natural dyeing with cotton can produce excellent results, e.g., cutch chocolate brown, deep indigo blue, brilliant madder red and bright weld yellow. By following the guidance above, there's no reason to be nervous of dyeing cotton. The difference between mediocre and very good dyeing often hinges on paying attention to what may appear to be minor details (Liles 1990).

I haven't provided quantities as this is an overview. Further details and recipes for fibre preparation, dye extraction, and dyeing methods can be found in Dean (2010), Boutrup and Ellis (2018), Hardman and Pinhey (2009), and Lambert and Kendall (2010). See also Wild Colours *www.wildcolours.co.uk* and Maiwa websites *https://maiwa.com*. For information on 'Turkey red', the intricate process of producing a deep fast red on cotton fibres, see Bamford (2016) and Wertz (2017).

Further Reading

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