# Colour stability and performance of vegetal dyes on natural fibres

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In the past natural dyestuffs were employed extensively to colour textiles, but their use has been progressively substituted by synthetic colours. Nowadays, we assist to a renewed interest being natural products safer both for humans and environment.

The respect of nature and human health underlies the search for low-impact production methodologies and materials; anyway, the choice of colours and fibres should ensure long-lasting and stable visual performance.

We investigated the chromatic robustness of some dyestuffs on cotton and silk samples and evaluated the colour changes they underwent after repeated washes or exposition to direct sunlight. Vegetal Woad, Weld and Madder, produced at the Museum of Natural Colours in Lamoli (PU, Italy) by non-dangerous traditional techniques, were selected to colour our sample textiles.

Dyeing textiles with natural substances is far more complex and difficult than with synthetic colours, that is the reason why many researches are in progress with the purpose of optimizing the dyeing of animal (wool and silk) and vegetal (cotton, linen,...) fibres.

All the samples we investigated have been coloured with different concentrations of both dyes and excipients and with different soaking times and temperatures of the colour bath. We monitored the chromatic stability of the samples through spectrophotometric techniques after washings and after exposition to direct sunlight; in particular, we calculated colour coordinates and chromatic differences as well, from the acquisitions of the Spectral Reflectance Factor (SRF).

Investigations were performed onto twin groups of samples: the first group was cyclically washed with a neutral commercial soap, whereas the second was continuously exposed to sunlight for a month.

Spectral measurements were performed both before and after treatments, in order to infer chromatic alterations.

Colour coordinates and chromatic changes were monitored with a contact spectrophotometer (Minolta CM-2600d, 10 nm spectral step, d/8° illumination-collection geometry with integrating sphere) returning SRF spectra in the 360-740 nm range. Colour data were calculated under the standard illuminant D65 and with the colour-matching functions associated with the standard 10° observer [1], in accordance with the recommendations of the Commission Internationale de l'Eclairage (CIE). SRF spectra are interpreted in the CIELab 1976 [2], whose axes describe the lightness L* (from 0-black to 100-white), redness-greenness component a* and yellowness-blueness component b* (both unbounded). Anyway our results are reported with cylindrical coordinates, where the perceptual attributes of chroma, C*, and of hue, h, substitute for a* and b* in a constant lightness plane [3].

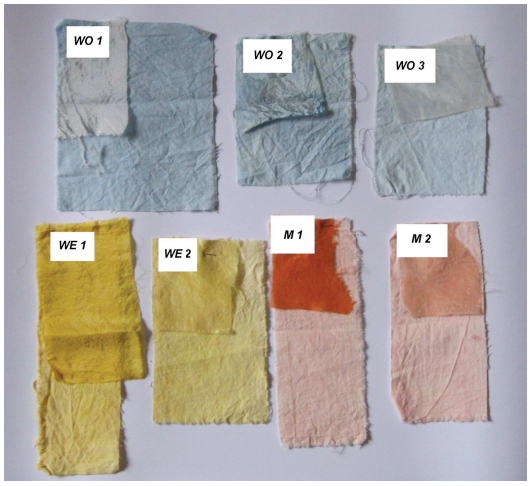


Figure 1. Samples coloured with different concentrations of dyes and excipients and with different soaking times and temperatures of the colour bath using Woad (WO 1, WO 2, WO 3), Weld (WE 1, WE 2) and Madder (M 1, M 2)

SRF spectra, taken from blank coloured samples (Fig.1), highlighted the spectrophotometric properties as a function of the different fibres and dyeing procedures. Regardless of the particular colour bath, *SRF* spectra acquired from any Woad dyed fibres show similar behaviour; whereas cotton samples exhibit differences with respect to silk dyed ones. Analogous considerations are inferred from Madder *SRF* spectra. In-

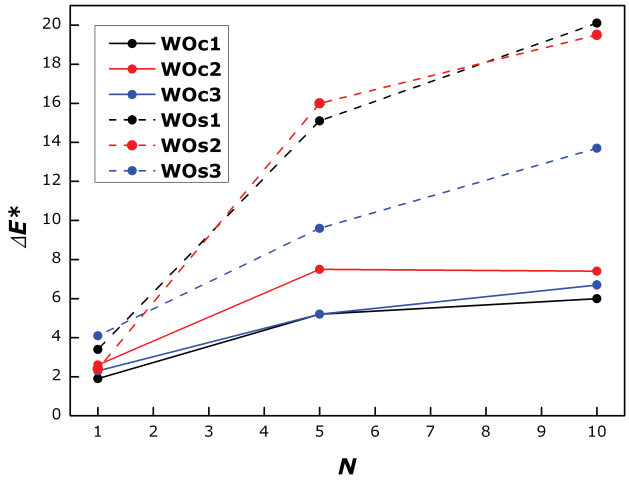


Figure 2. Colour distance versus number of washings for Woad samples (-c and -s refer to cotton and silk fibres, respectively)

stead Weld spectra seem to be insensitive both to colour bath and hosting fibre. From the chromatic point of view, L*, C* and h coordinates confirm the different visual conclusions that can be drawn with respect to colour baths and fibres. In order to monitor the stability of dyes, spectrophotometric acquisitions were systematically repeated after 1, 5 and 10 washings with a common commercial soap. For each sample the colour distance, from the respective blank one, has been calculated.

Figure 2 shows, as an example, the plots of Colour distance, $\Delta$E*, versus the number of washings, N, for Woad dyed samples.

Colour distance increases with N; in particular, in Woad the main contribution to colour variation can be ascribed to lightness, with the exception of some samples where chroma dominates; in Weld, chroma loads the total difference; in Madder, it is lightness to make the difference, although significant percent variations of chroma and hue are noticed, too.

Figure 2 demonstrates that dyeing with Woad is more stable on cotton, whereas the alterations induced on silk are restrained by the action of the casein glue added to the colour bath. Colour is less prone to fade away from Weld and Madder dyed silk samples and it must be pointed out that colour bath has opposite effects on the different fibres.

For the sake of quantifying sunlight induced chromatic changes, non-irradiated samples served as reference for colour differences. Weld on cotton is the most daylight sensitive dyestuff and chroma reduction dominates the $\Delta$E* values both on silk and cotton. The net effect of sun irradiation on Madder samples is essentially some kind of discoloration. Considerations cannot be made for Woad samples as a whole, because the situation is rather complex.

From investigations it comes out that particular attention must be paid to the selection of the most suitable dyeing procedures, alkalizers, precipitants, fixatives, mordants, colour bath concentration, temperature and time for each particular fibre and dyestuff, considering the final field of application.

The results of this work will be exploited by specialists to revise their dyeing processes for the combinations of dyestuffs and fibres.

## REFERENCES

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