



# DYEING OF COTTON WITH MADDER USING (BIO)MORDANTS: EFFECTS ON FASTNESS AND UV PROTECTION PROPERTIES

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*Rubia tinctorum* L.

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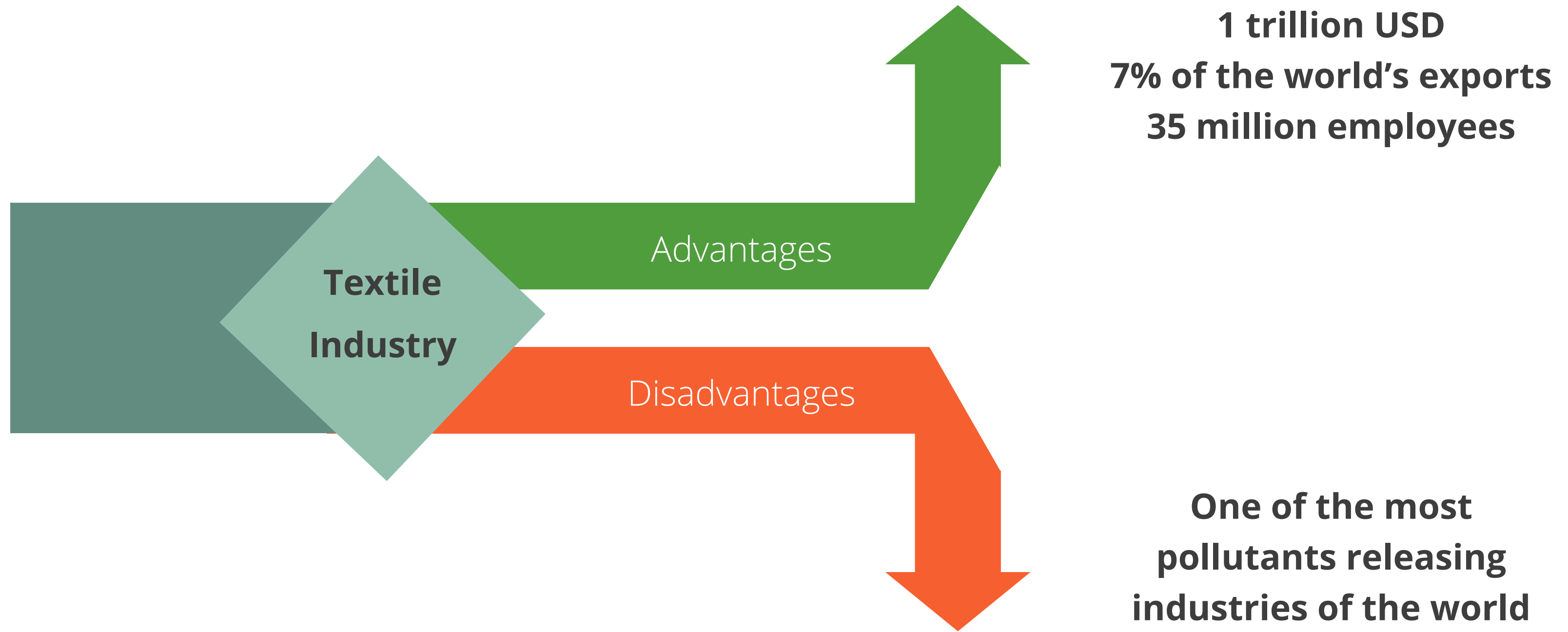
CIELab colour coordinates

Colour strength (K/S)

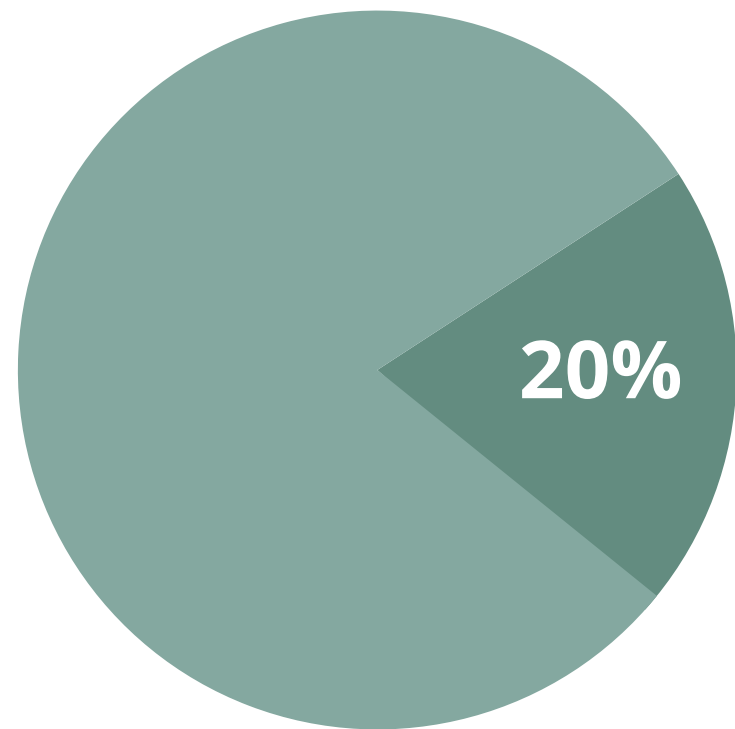
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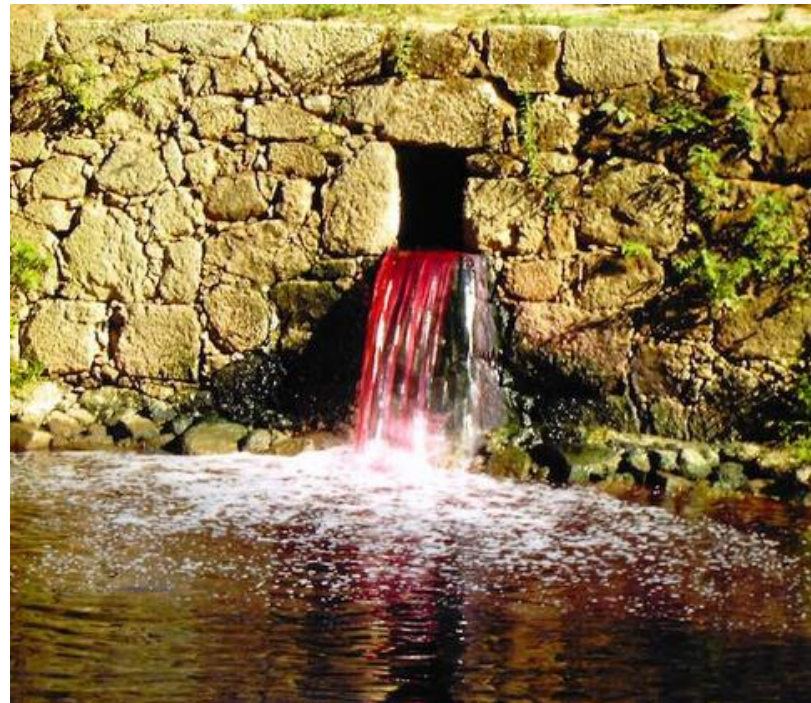
## Conclusions



# Environmental impact of the textile industry



**World's  
wastewater**



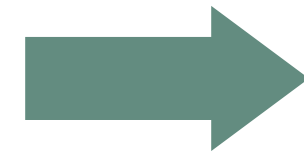
**High levels of BOD and COD**

**Non-biodegradable organic compounds (e.g., dyes)**

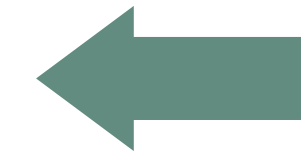
**Synthetic dyes are potentially toxic, mutagenic, and carcinogenic**

**15-50% azo dyes do not bind to the fabric**

Sources



## NATURAL DYES



Function

- Plants
- Minerals
- Microbes
- Insects
- Lichens



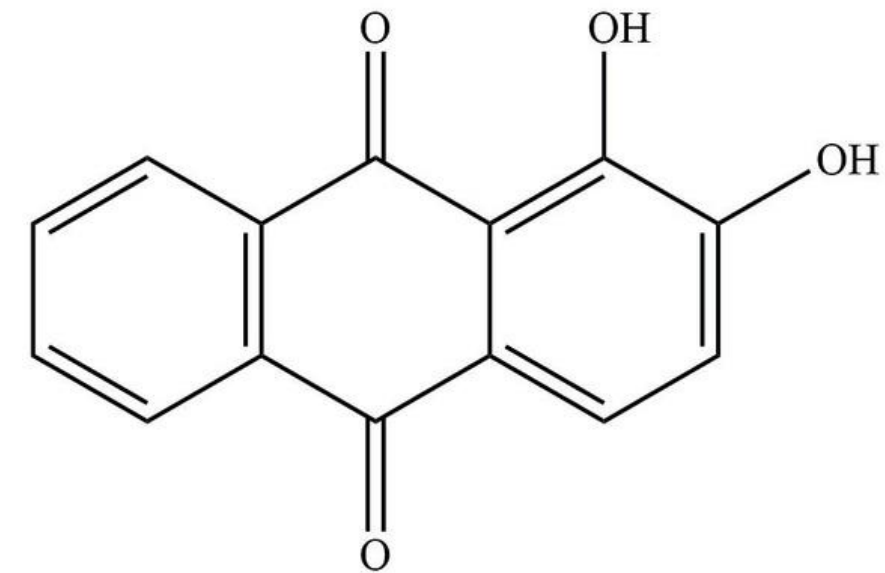
- Coloration
- Antimicrobial
- UV protection
- Deodorizing

**Ecological alternative to synthetic dyes**

# Rubia tinctorum L. (Madder)



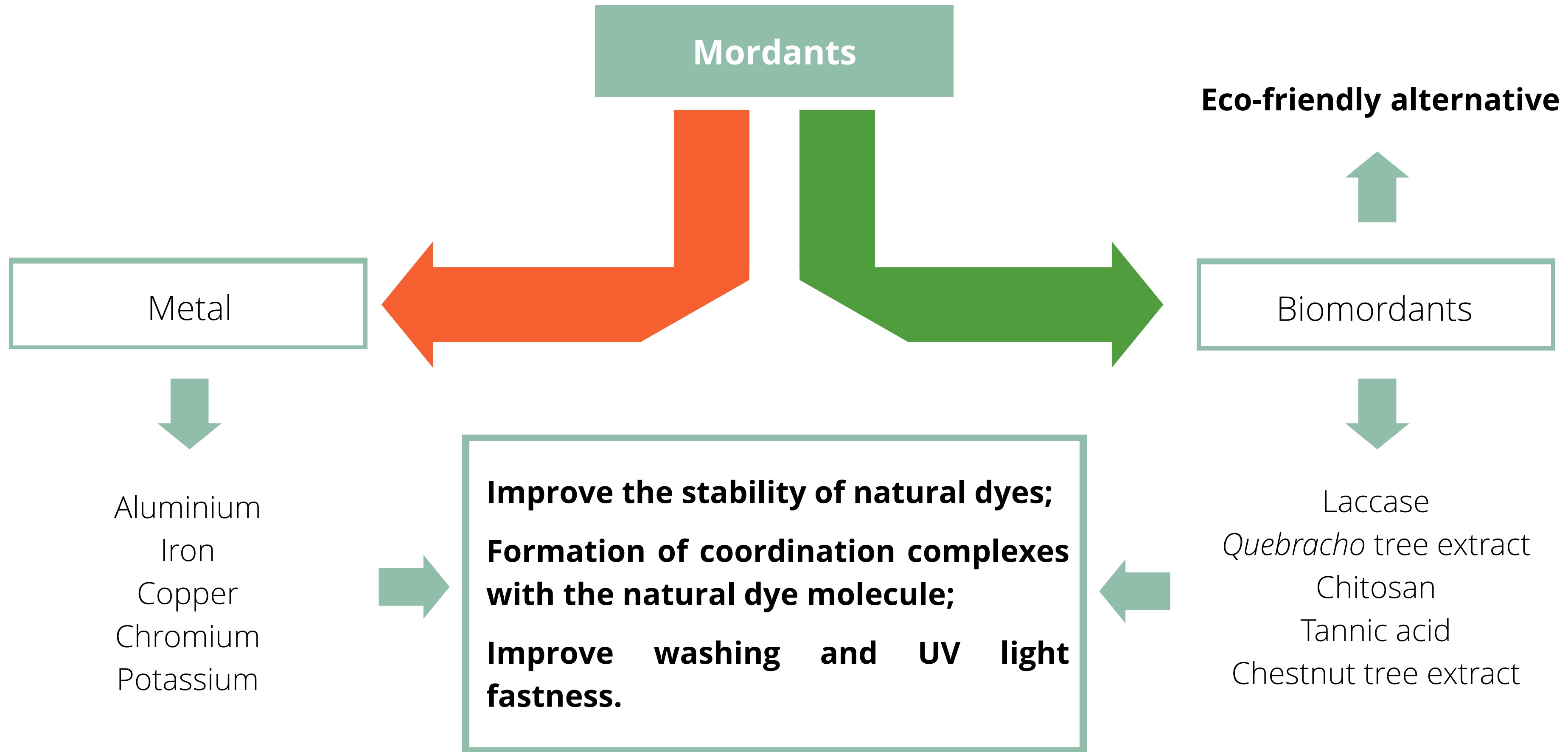
**Figure 1.** European Madder.



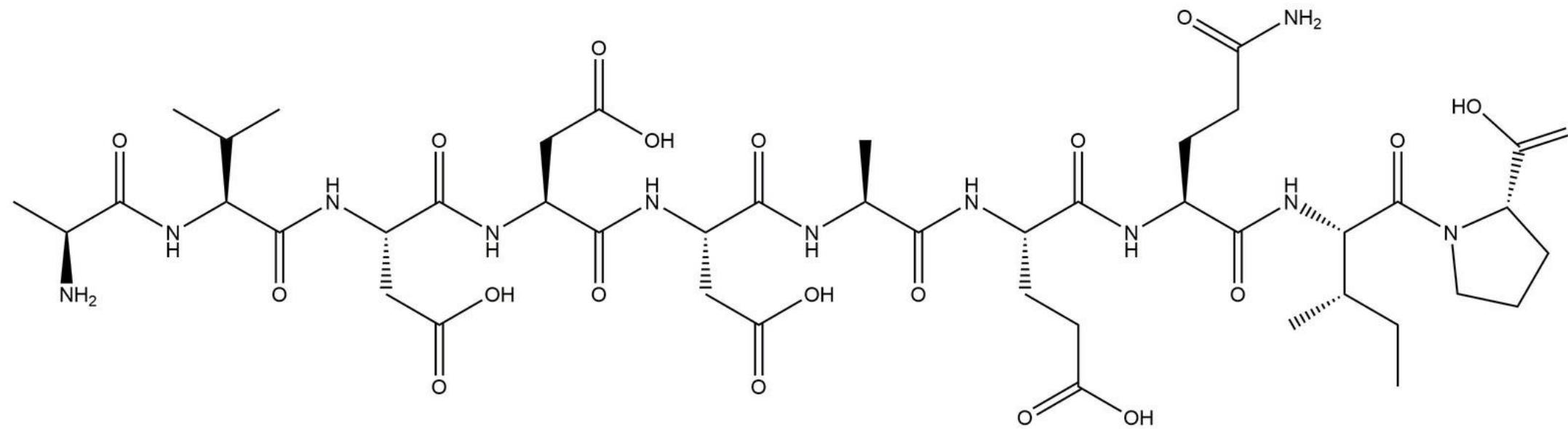
**Alizarin** (Anthraquinone)



Low affinity for cotton fabrics, interaction mostly via weak Van der Waals forces, hydrogen bonding, and hydrophobic interactions.



# Laccase



**Figure 2.** Chemical structure of laccase.

Multicopper polyphenol enzyme capable of oxidizing phenolic hydroxyl

by

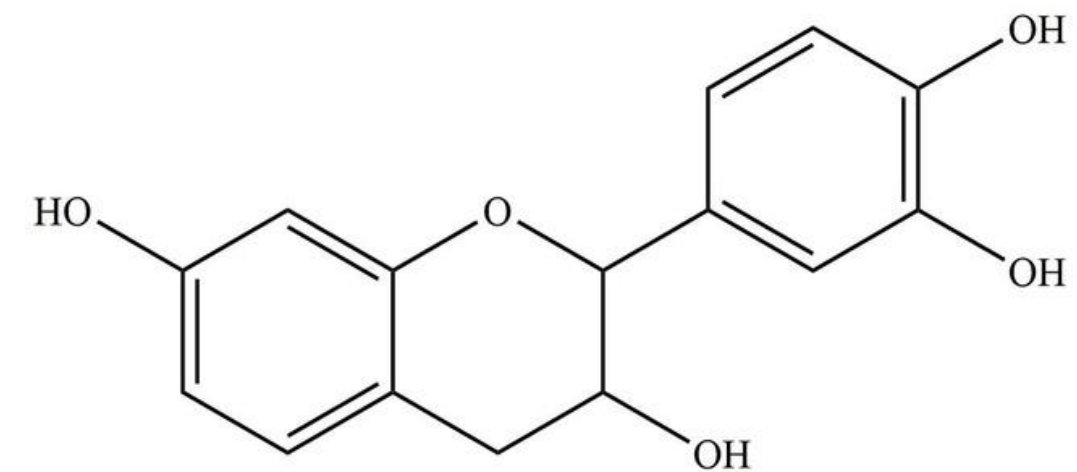
One-electron oxidation of phenolic to form phenoxy free radicals

**Laccase can contribute to obtaining deeper colours and enhance the fastness of the dyes by polymerization of natural dyes containing phenolic hydroxyl groups**



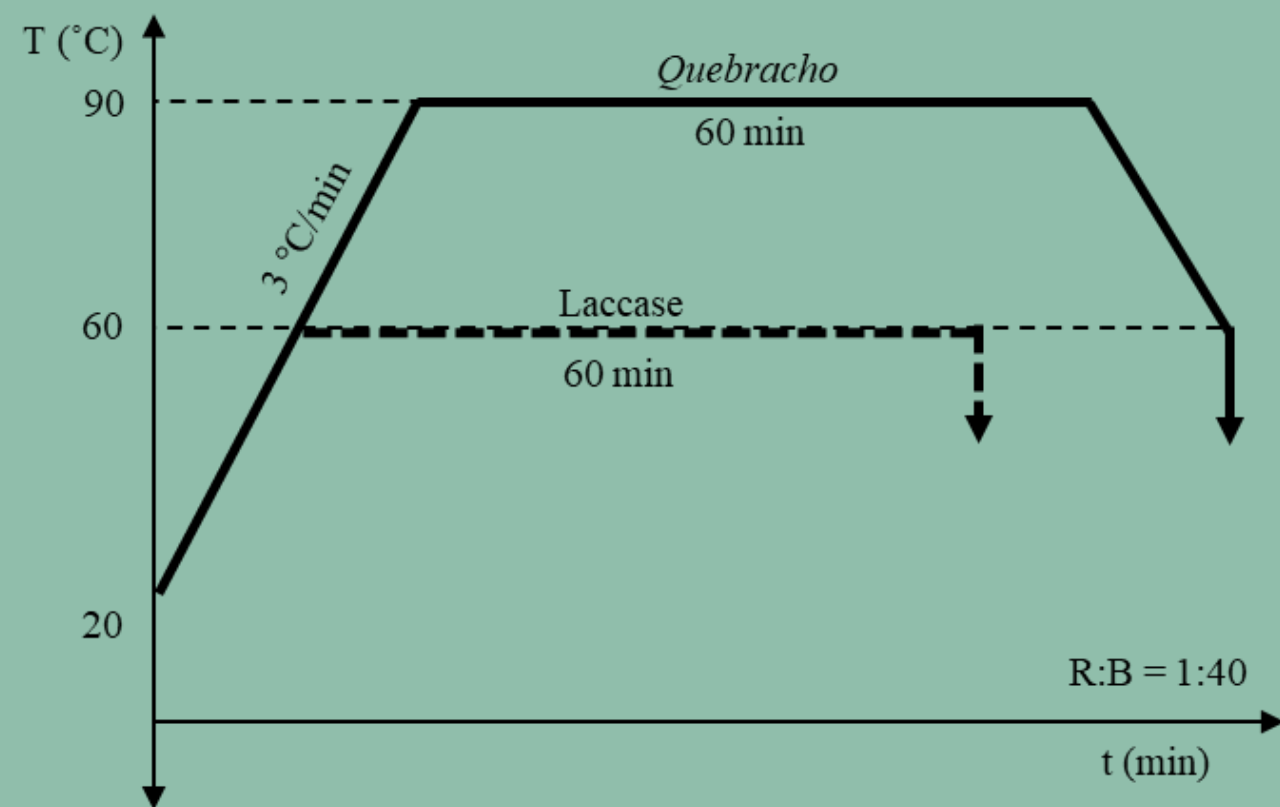
# Quebracho tree extract

- Source of condensed tannins (~20%);
- Tannins are naturally occurring water-soluble polyphenolic compounds;
- These groups help in colour fixation by forming effective crosslinks with fibres and dyes;
- Tannins are often combined with a metal salt to improve the overall fastness of natural dyes;
- Can improve washing and UV light fastness, as well as UPF.



**Figure 3.** Quebracho tree extract (*Schinopsis spp.*) (source and chemical structure).

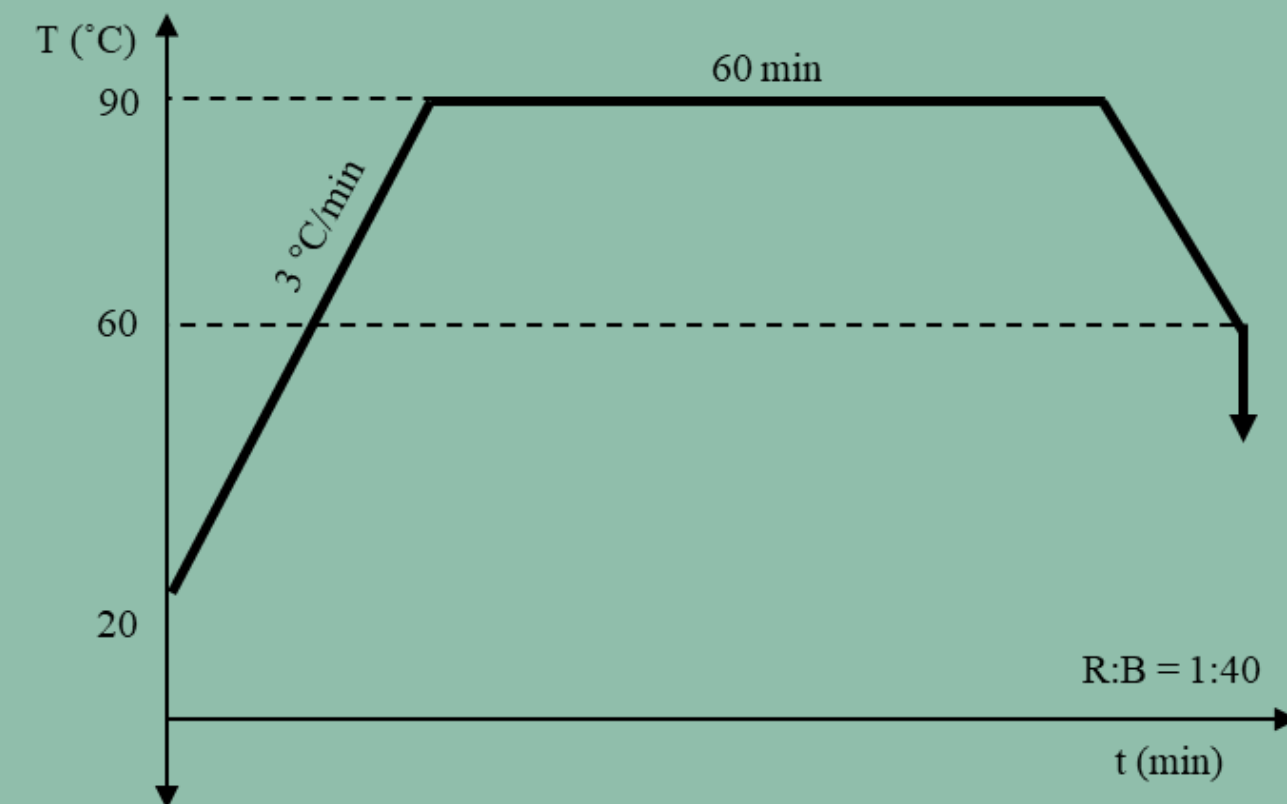
## Pre-treatment - Mordanting



Cotton fabric  
0.1% FeSO<sub>4</sub> or AlKSO<sub>4</sub>  
5% o.w.f. of quebracho or laccase

**Washing:** Distilled water  
**Drying:** 40 °C

## Dyeing - Exhaustion method



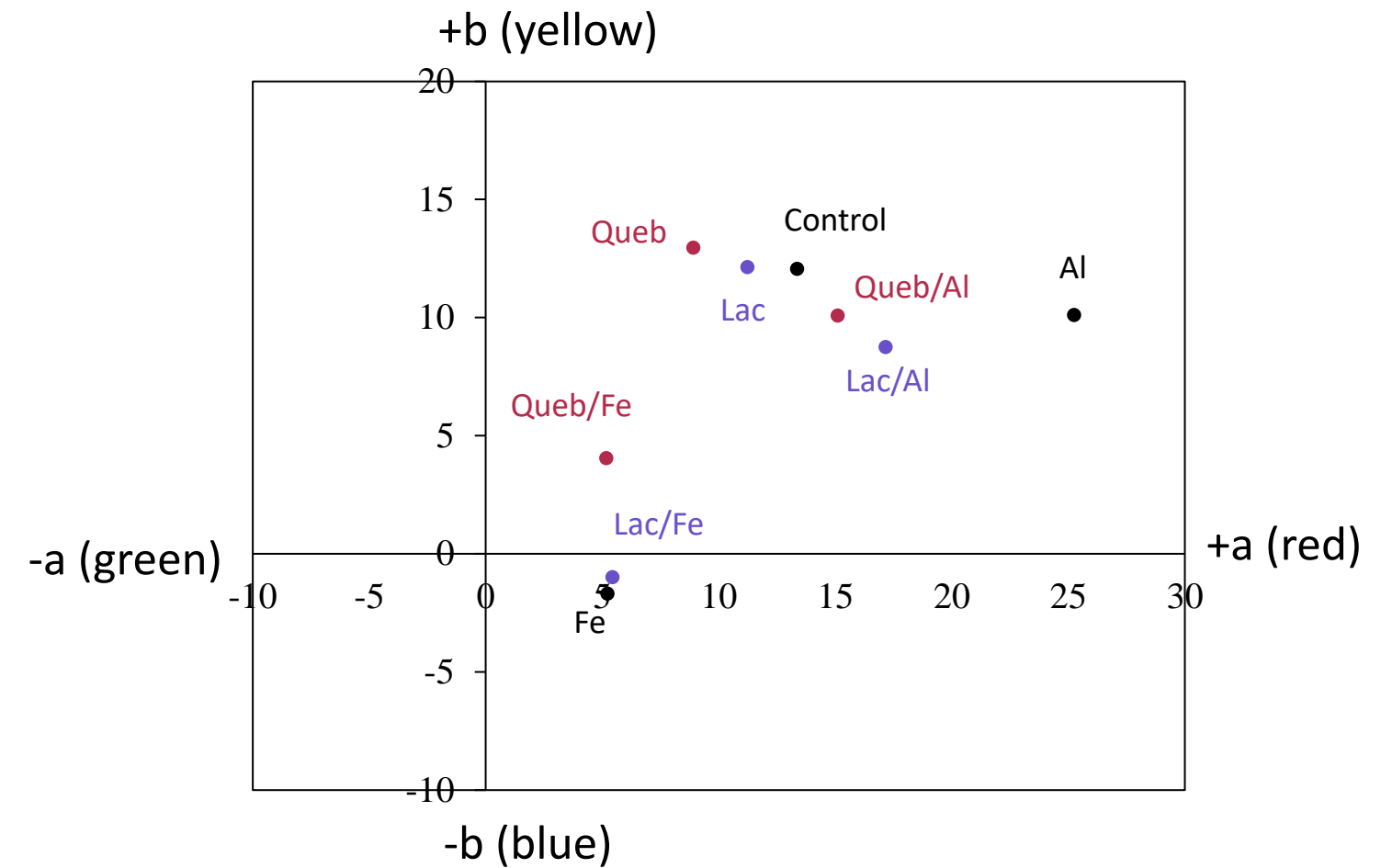
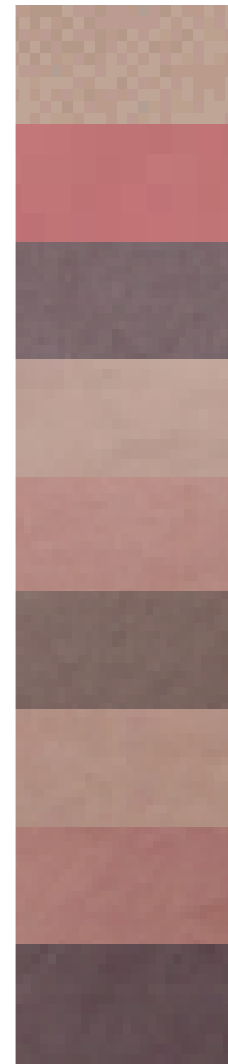
Untreated and pre-mordanted cotton fabric  
3% o.w.f. madder extract

**Washing:** Distilled water  
**Drying:** 40 °C

# CIELab colour coordinates

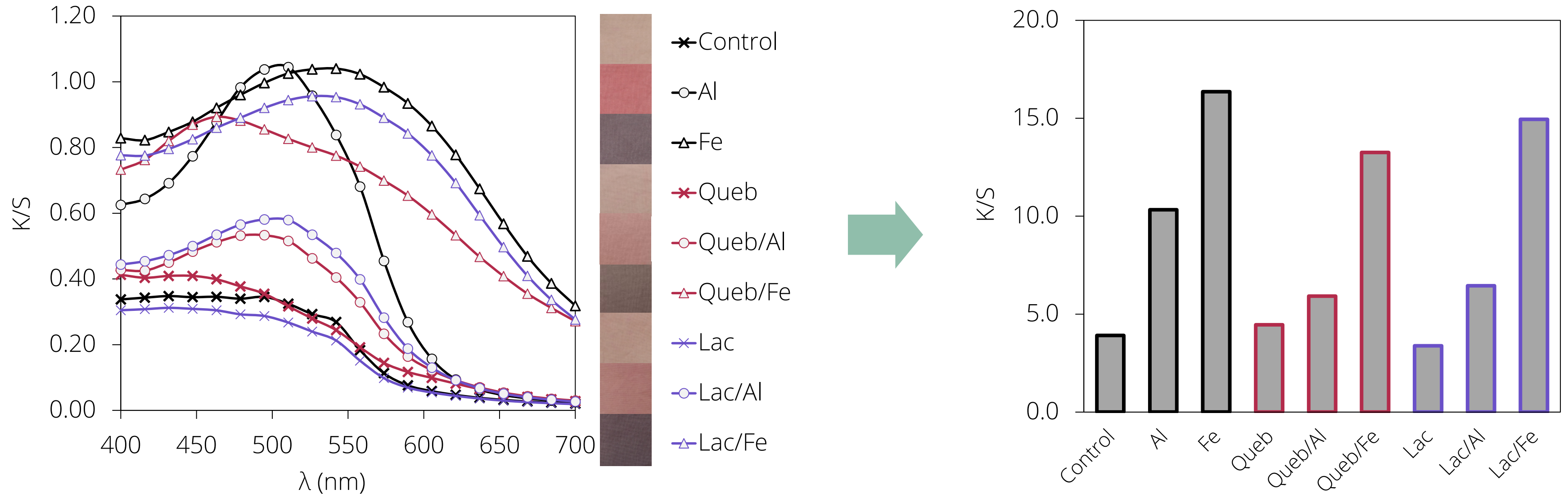
**Table 1.** CIELab colour coordinates.

	<b>L</b>	<b>a*</b>	<b>b*</b>
<b>Control</b>	79.58	13.36	12.06
<b>Al</b>	67.74	25.25	10.10
<b>Fe</b>	59.39	5.22	-1.69
<b>Queb</b>	78.44	8.91	12.95
<b>Queb/Al</b>	74.34	15.10	10.07
<b>Queb/Fe</b>	63.34	5.17	4.05
<b>Lac</b>	80.99	11.23	12.13
<b>Lac/Al</b>	72.97	17.15	8.75
<b>Lac/Fe</b>	60.70	5.44	-1.00



**Figure 4.** CIELab colour coordinates.

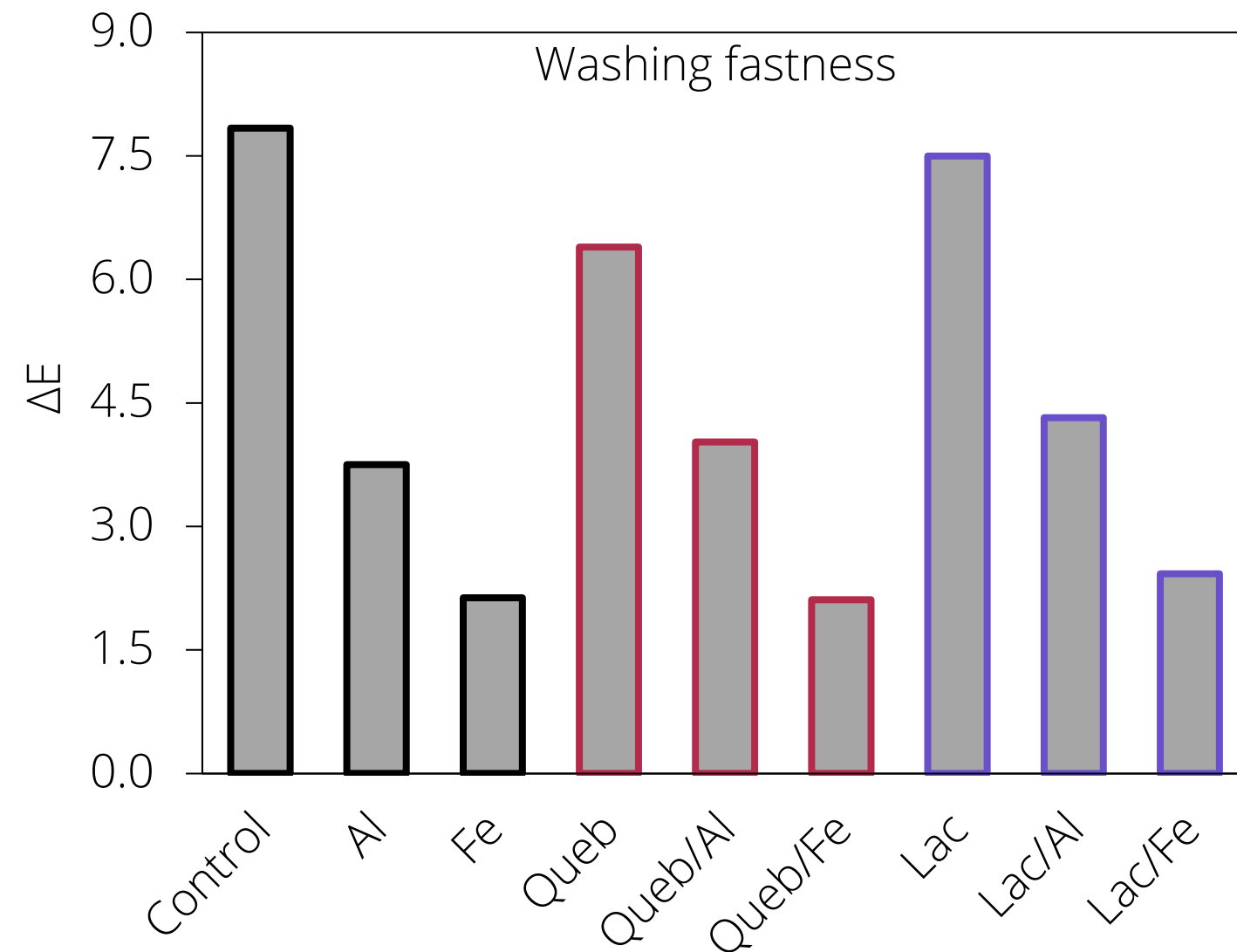
# Colour strength (K/S)



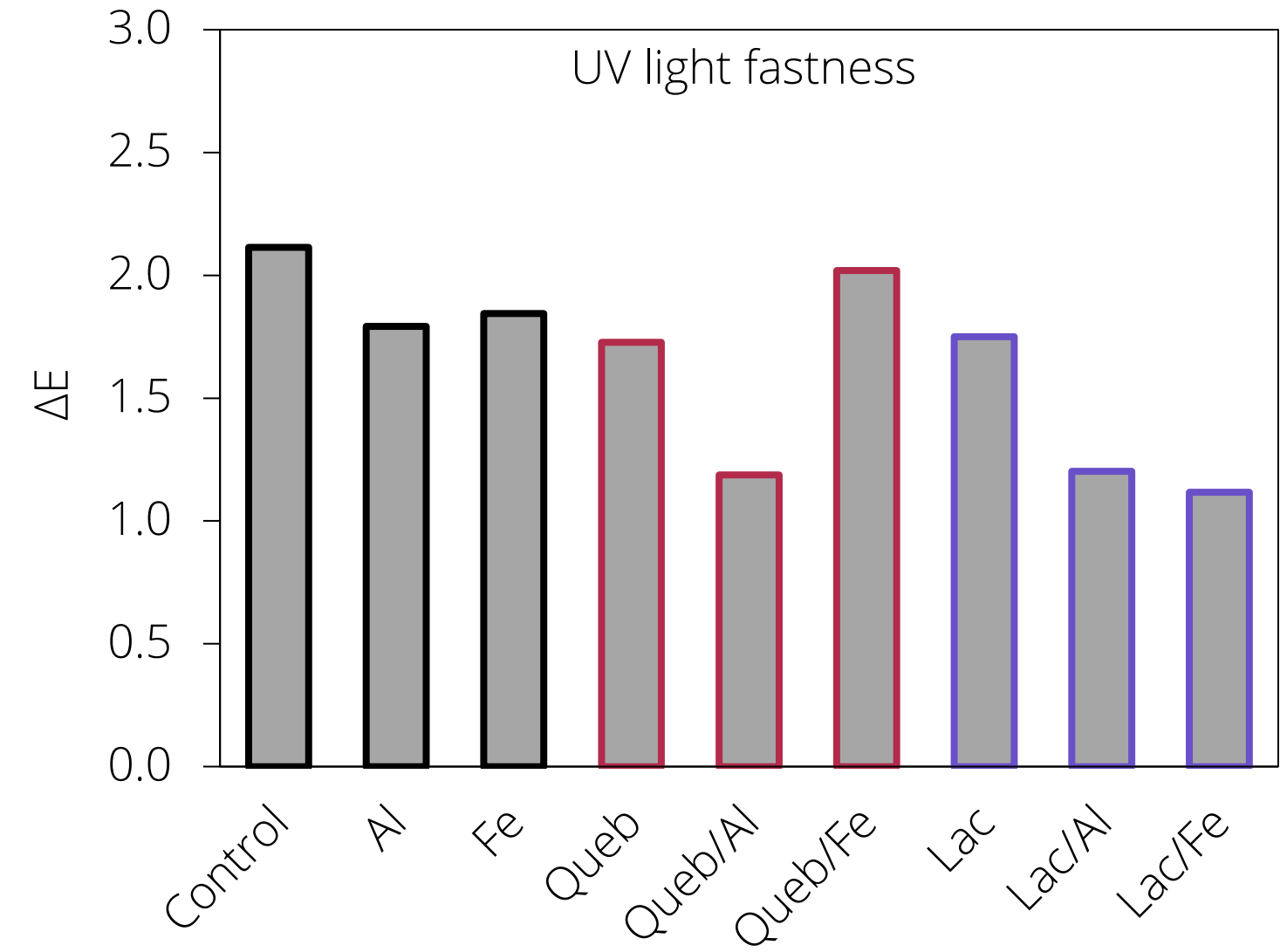
**Figure 5.** Colour strength (K/S) of the dyed samples.

- After treatment with the metal compounds, there was an improvement in the K/S (higher in Fe);
- Lac/Fe and Queb/Fe samples showed superior K/S than the others;
- Samples treated with laccase and metals showed a higher K/S than those treated with *quebracho*;
- Laccase and *quebracho* seems to be a viable option to reduce the use of metallic mordants in the textile industry.

# Fastness properties



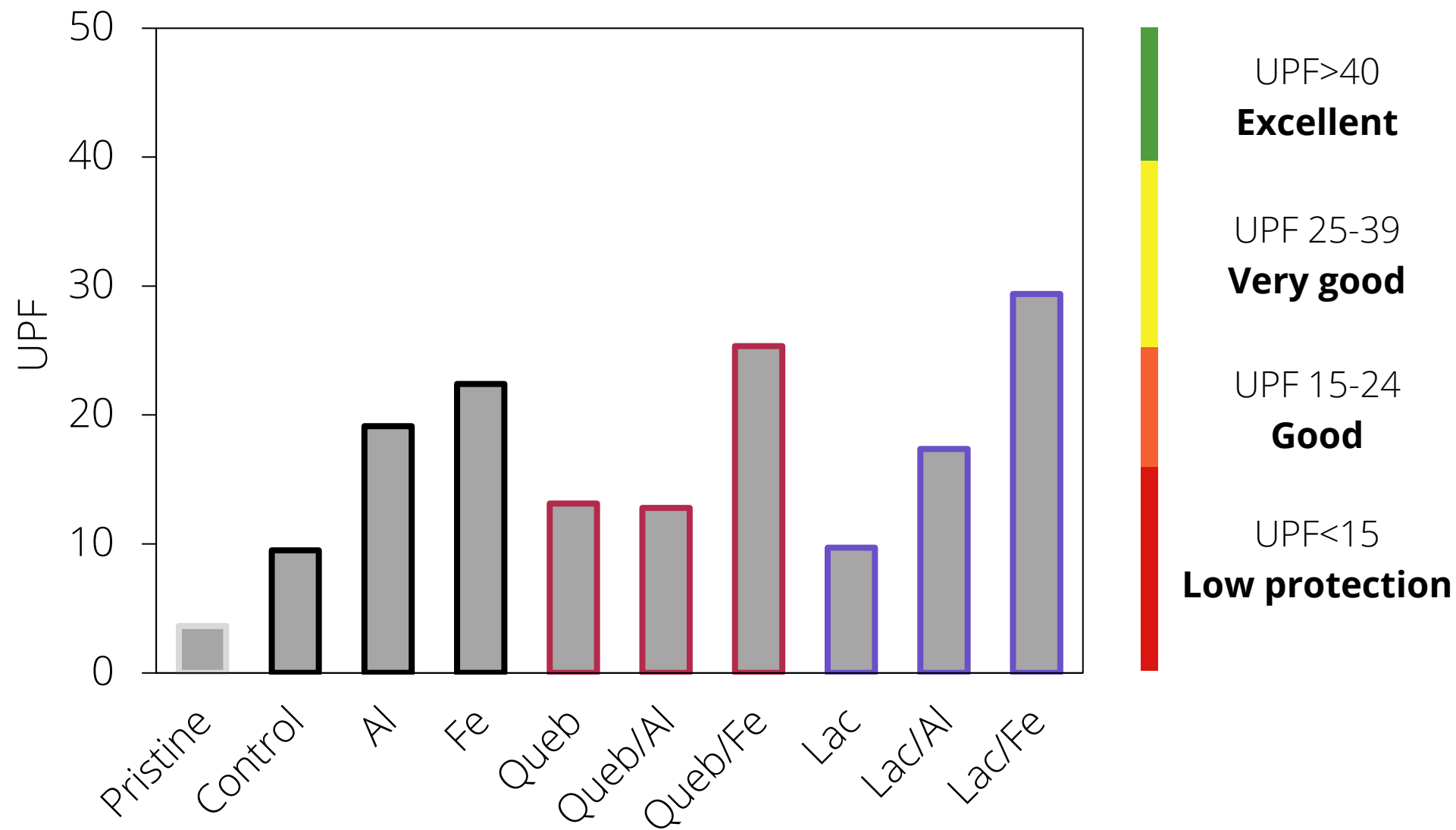
**Figure 6.** Washing fastness of the samples.



**Figure 7.** UV light fastness of the samples.

- In general, the inclusion of the metals, in their form and together with the tannin and the enzyme, improved the properties under analysis;
- Iron-treated samples showed more favorable washing fastness results than other treatments;
- Both aluminum and iron treated samples showed better light fastness than untreated samples, except in Que/Fe samples.

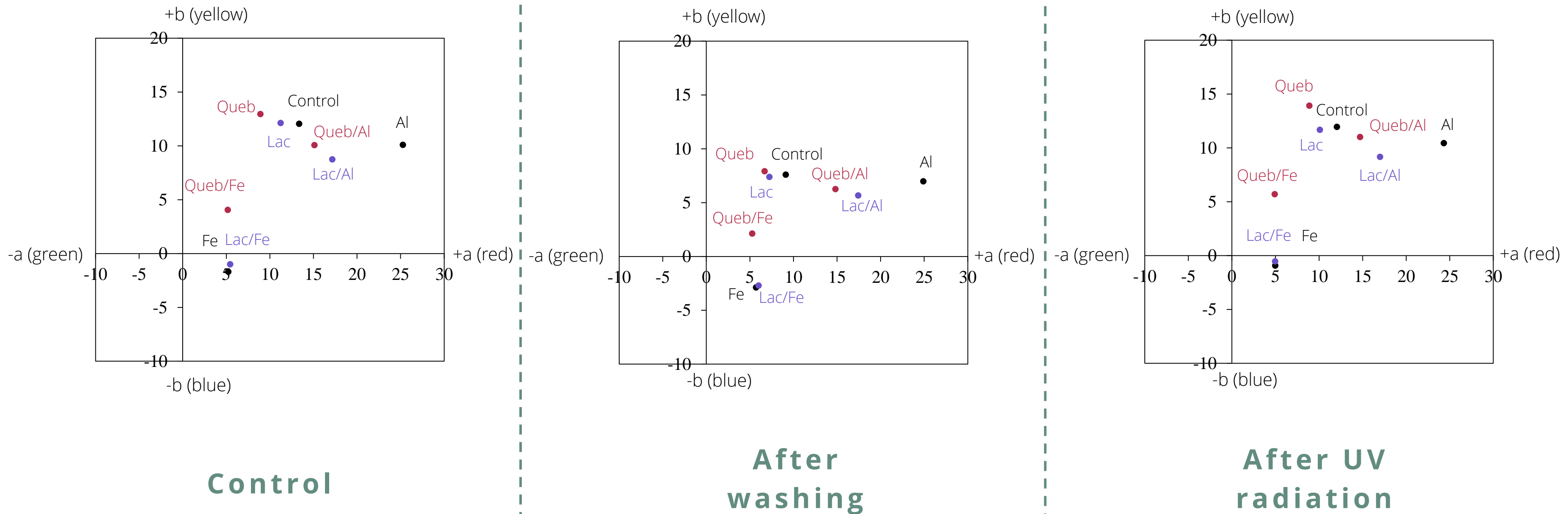
# UV protection factor (UPF)



**Figure 8.** UV protection (UPF) of the dyed samples.

- Samples treated with Fe present better results when compared to Al;
- Lac/Fe and Queb/Fe samples show very good UV protection (UPF=25–39). This fact occurs due to the high value of K/S and indicates that the complexation between iron and tannin or enzyme improved this property;
- K/S, fastness properties, and UPF were improved after treatments with metallic mordants and biomordants.

# Colour Strength



**Figure 9.** Colour strength of the dyed samples.

# Conclusions

The application of biomordants seems to be a viable option to reduce the use of metallic mordants in the textile industry.

All the properties in study were improved when the pre-treatment with the *quebracho* was performed.

Therefore, although it was impossible not to use metallic salts, the application of biomordants significantly reduced the need for their use.

In the case of laccase, only an improvement in UV light fastness was observed.

The need to use reduced amounts of metals has been proven to achieve good UV light fastness and UV protection properties.



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**Thank you**