

The 43rd International
Conference
**Dyes in History and
Archaeology**

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www.dha43.org



Use of alkali in traditional dyeing technologies with plants

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Sources

- Unpublished written sources:
 - Ethnographical materials collected by the Board of Monuments **1924-1943** (Latvian National Museum of History)
 - Descriptions from ethnographical expeditions **1947-1989** (Repository of Ethnographical Materials of the Institute of Latvian History of the University of Latvia)
- Published sources:
 - Publications in the Latvian press (**1893-1944**)
 - Bielenstein, Martha, **1935**. *Die altlettischen Färbmethoden. Studien zur indogermanischen Altertumskunde*. Veröffentlichungen der volkskundlichen Forschungsstelle am Herderinstitut zu Riga, Band II, Riga: Druck u. Verlag der AG "Ernst Plates"
- Practical dyeing experiments
- Chemical analyzes

Written information for red/reddish color

- **1895.** *Austrums*, nr. 1:
For dyeing the **red shade, brownish red**, (..) the roots of tormentil were used, for which the plant itself was used, and only its roots.
- **1923.** *Latvijas Saule*, nr. 4:
Tormentil is found in forests, meadows, and fields. The roots, which give yellow, **red**, and black colors, are used in dyeing.
- **1931.** *Zeltene*, nr. 7
- **1933.** LNVM ZAE Collection Nr.35, Daugavpils distr.:
If [the girl] had black hair, then **red** stripes [in her skirt]. Woolen yarn [for them] was dyed in tormentil roots.
- **1935.** Bielenstein. *Die altlettischen Färbmethoden*, p. 104, 109



POTENTILLA ERECTA (L.) RAEUSCH.

Written information for red/reddish color

RUMEX ACETOSA L.

- **1931.** Zeltene, nr. 7:
Sorrel (*Rumex acetosa*) - roots - **brown-red**, whole plant - brown and black colors.
- **1935.** Bielenstein. *Die altlettischen Färbmethoden*, p. 105:
Rumex acetosa. Roots, leaves, flowers: **brown to reddish brown**.
- **1943.** Tēvija, nr. 164:
(..)from the sorrel roots - **red-brown**



Black and greenish-gray colors

- Latvijas Saule. 1923, no. 4:
Sorrel (*Rumex*) is used fresh; it provides a permanent **black** color.
- Zeltene. 1927, no. 12:
Sorrel (*Rumex*). We can find it almost everywhere. Used fresh, it gives a **black** color.
- Zeltene. 1931, no. 7:
Sorrel (*Rumex acetosa*) - roots [give] - brown-red, whole plant - **brown** and **black** colors.
- Bielenstein, 1935, p.109:
Potentilla silvestris [*Potentilla erecta*].
Stem: yellow; root: red; whole plant: **black**.



Dyeing experiments



Rumex acetosa

300 g dried root

Soaked in **plain water** for **48 h**, final **pH 5.5**

Boiled for **2 hours**, strained and cooled

Wool yarn samples (5 x 5g) were mordanted with:

Without mordanting

Alumn + cream of tratar

Tin salt

Copper sulphate

Iron sulphate

premordanted

premordanted

In the time of dyeing

In the time of dyeing

Slowly heated to **85-90 degrees**, continued heating for **45 minutes**, cooled in dye solution

300 g dried root

Soaked in alkali **pH13**, after **48h** - **pH 6**

Boiled for **2 hours**, strained and cooled

Wool yarn samples (5 x 5g) were mordanted with:

Without mordanting

Alumn + cream of tratar

Tin salt

Copper sulphate

Iron sulphate

premordanted

premordanted

In the time of dyeing

In the time of dyeing

Slowly heated to **85-90 degrees**, continued heating for **45 minutes**, cooled in dye solution

Rumex acetosa L.

	Linen	Wool				
Soaked in alkali	 Iron sulphate 					
	Without mordant	Without mordant	Alum + cream of tartar	Tin salt	Copper sulphate	Iron sulphate
Soaked in water		 < 50° C  85° C				

Potentilla erecta

548 g fresh root (corresponding to ~ 300g dried root)

Soaked in **plain water** for **24 h**, final **pH 5.5**

Boiled for **2 hours**, strained and cooled

Wool yarn samples (5 x 5g) were mordanted with:

Without mordanting

Alumn + cream of tratar

Tin salt

Copper sulphate

Iron sulphate

premordanted

premordanted

In the time of dyeing

In the time of dyeing

Slowly heated to **85-90 degrees**, continued heating **for 45 minutes**, cooled in dye solution

548 g fresh root (corresponding to ~ 300g dried root)

Soaked in alkali **pH13**, after **72h** - **pH 6**

Boiled for **2 hours**, strained and cooled

Wool yarn samples (5 x 5g) were mordanted with:

Without mordanting

Alumn + cream of tratar

Tin salt

Copper sulphate

Iron sulphate

premordanted

premordanted

In the time of dyeing

In the time of dyeing

Slowly heated to **85-90 degrees**, continued heating **for 45 minutes**, cooled in dye solution

Potentilla erecta

		Wool				
Linen						
Soaked in water						
	Without mordant	Without mordant	Alum + cream of tartar	Tin salt	Copper sulphate	Iron sulphate
Soaked in alkali						 
						Premordanted with rust water



Betula pendula Roth underbark

	Linen	Wool				
Soaked in water						
	Without mordant	Without mordant	Alum + cream of tartar	Tin salt	Copper sulphate	Iron sulphate
Soaked in alkali						

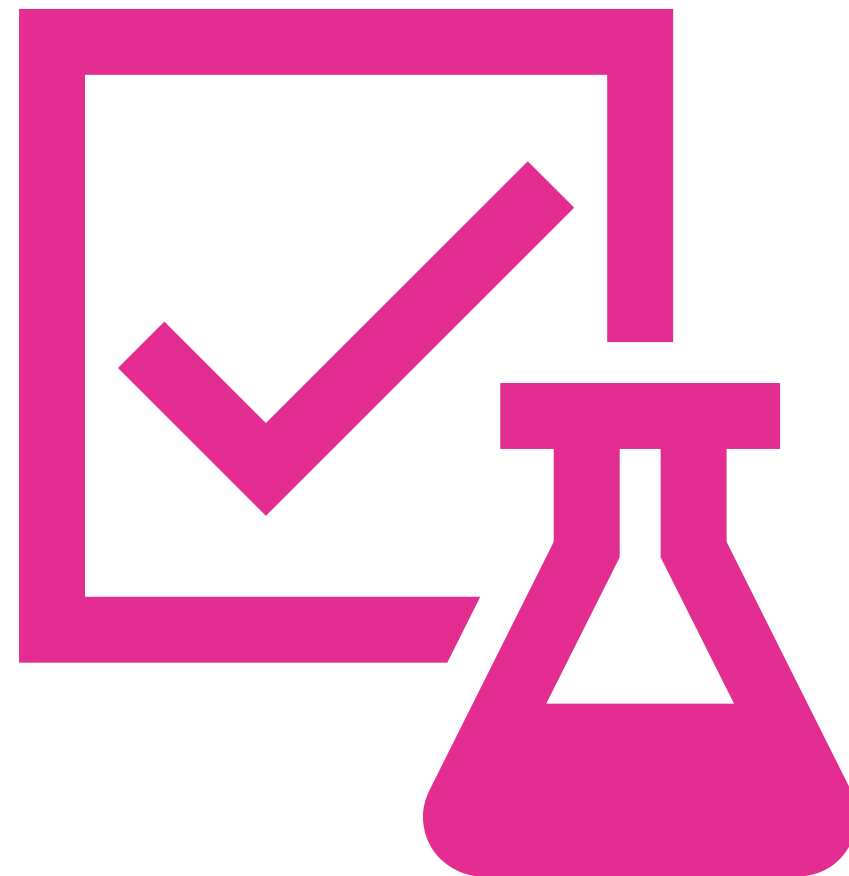
Padus avium Mill. bark



Wool				
Soaked in water				
	Without mordant	Alum	Copper sulphate	Iron sulphate
Soaked in alkali				

*Chemical
analyzes*

POTENTILLA ERECTA L.



Chromatography condition

Column: UPLC BEH™ C18 1.7 μm (2.1 x 150 mm)

Column temperature: 35 °C

Mobile Phase A: 0.3% Formic Acid in H₂O

Mobile Phase B: MeOH (composition gradient elution mode -

5.2/94.8 → 80.1/19.9) **Flow rate:** 0.25 mL/min

Injection volume: 2 μL

PDA detection: 278 nm

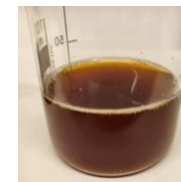
Ionization: (ESI-)

Mass range: m/z 75 – 2000

Acquisition mode: selected ion recording (SIR)



Waters Acquity UPLC – MS/MS



water solution



alkaline-hydrolysis
solution

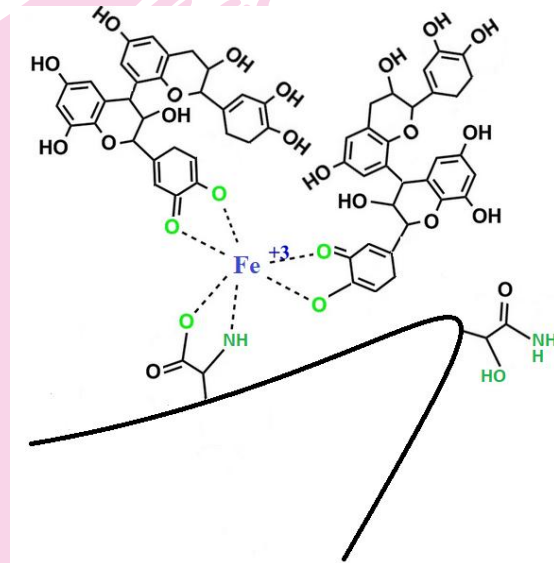
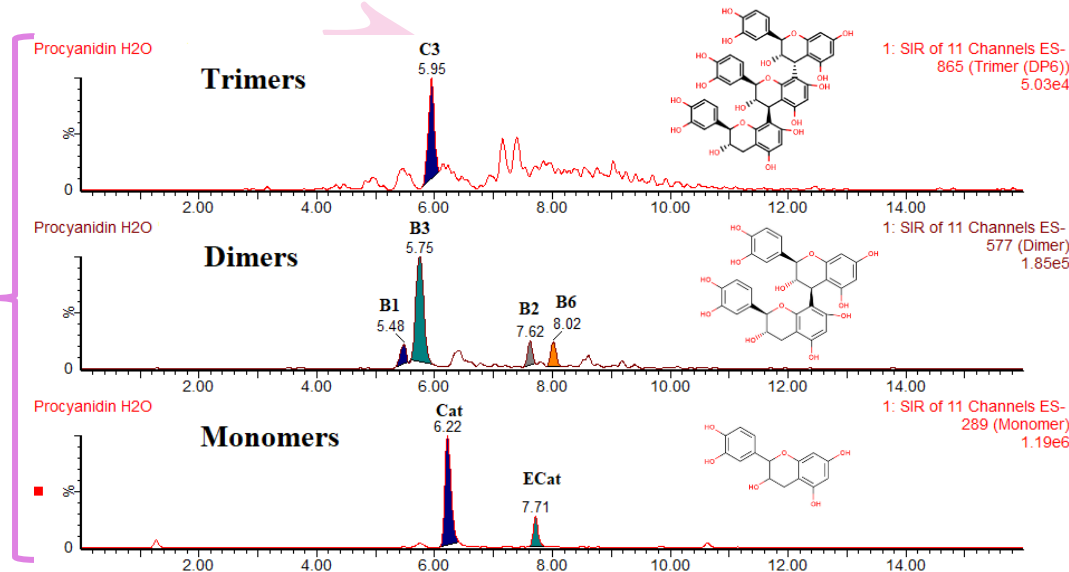
Potentilla erecta L.

Composition of coloring pigments of root extracts - procyanidin

Water
maceration
extraction –
24 h



chromatography

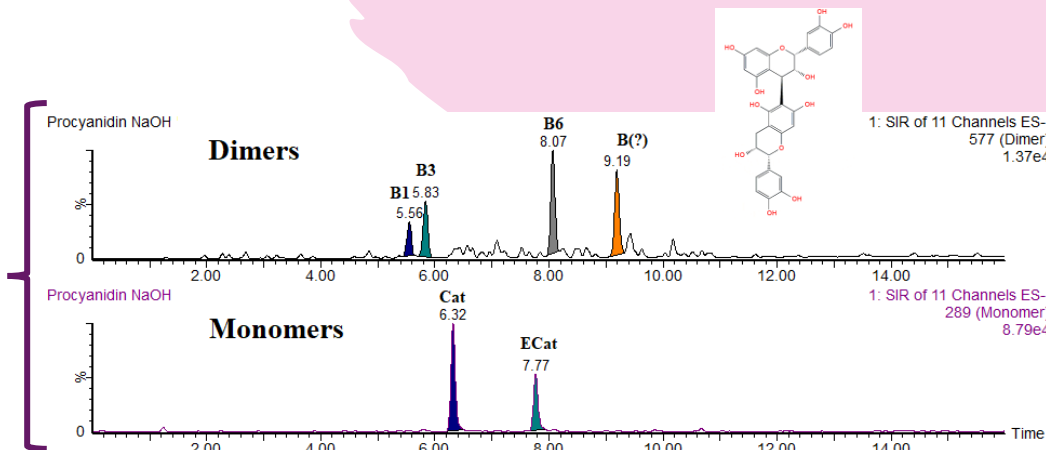


Possible metal complex structure between Tormentil root extract's main colorant and wool.

Alkaline
maceration
extraction –
120 h



chromatography



Monomers – (+)-Catechin (**Cat**); (-)-Epicatechin (**ECat**); **Dimers** – (-)-Epicatechin-[\beta4,8]-(+)-Catechin (**B1**); (-)-Epicatechin-[\beta4,8]-(-)-Epicatechin (**B2**); (+)-Catechin-[\alpha4,8]-(+)-Catechin (**B3**); (+)-Catechin-[\alpha4,6]-(+)-Catechin (**B6**); (+)-Catechin-[6',6]-(+)-Catechin (**B?**); **Trimers** – (-)-Epicatechin-[\beta4,8]-(+)-Catechin-[\alpha4,8]-(+)-Catechin (**C3**).

Procyanidin content



$m_{\text{pigments}}^{\text{water-soluble}} = 2.21 \pm 0.05 \text{ g/kg DW root}$
 $m_{\text{monomers}}^{\text{procyanidin}} = 10.00 \pm 0.40 \text{ mg/g extract}$
 $m_{\text{dimers}}^{\text{procyanidin}} = 5.18 \pm 0.10 \text{ }\mu\text{g/g extract}$
 $m_{\text{trimers}}^{\text{procyanidin}} = 0.56 \pm 0.02 \text{ }\mu\text{g/g extract}$

1:14.4
Wool fiber
Fresh roots
Without mordanting



CMYK COLOR: cmyk(0, 25, 35, 5)
Name Alias: Wax Flower
HEX Color: #F2B59D
RGB Values: rgb(242, 180, 156)
cmyktool.com



$m_{\text{pigments}}^{\text{alkaline-soluble}} = 4.21 \pm 0.09 \text{ g/kg DW root}$
 $m_{\text{monomers}}^{\text{procyanidin}} = 1.57 \pm 0.05 \text{ mg/g extract}$
 $m_{\text{dimers}}^{\text{procyanidin}} = 6.76 \pm 0.11 \text{ }\mu\text{g/g extract}$

1:14.4
Wool fiber
Fresh roots
Without mordanting



CMYK COLOR: cmyk(10, 55, 80, 25)
Name Alias: Vindaloo
HEX Color: #AC5626
RGB Values: rgb(172, 86, 38)
cmyktool.com

Alkaline maceration
extraction – 120 h

Water maceration
extraction – 24 h

CMYK COLOR: cmyk(20, 60, 70, 20)
Name Alias: Krakatoa
HEX Color: #A3513D
RGB Values: rgb(162, 80, 60)
cmyktool.com

$\text{KAl}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$ +
Potassium tartrate

CMYK COLOR: cmyk(35, 50, 60, 10)
Name Alias: Triple Rickshaw
HEX Color: #95725B
RGB Values: rgb(148, 114, 90)
cmyktool.com

CuSO_4

CMYK COLOR: cmyk(15, 55, 65, 15)
Name Alias: Brown Rust
HEX Color: #B8614B
RGB Values: rgb(184, 96, 74)
cmyktool.com

SnCl_2

CMYK COLOR: cmyk(0, 15, 23, 2)
Name Alias: Tuft Bush
HEX Color: #F9D4C0
RGB Values: rgb(248, 212, 192)
cmyktool.com

SnCl_2

CMYK COLOR: cmyk(40, 55, 50, 5)
Name Alias: PMS5205
HEX Color: #916D79
RGB Values: rgb(144, 108, 120)
cmyktool.com

FeSO_4

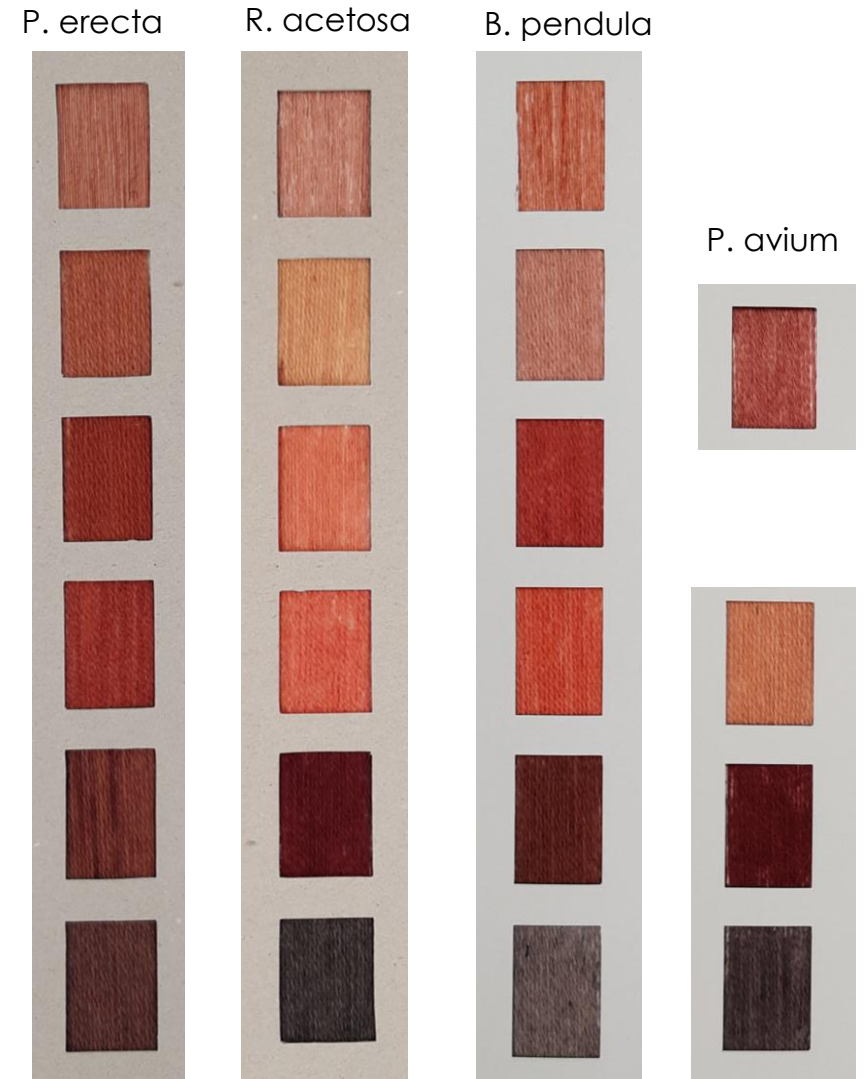
CMYK COLOR: cmyk(40, 50, 50, 0)
Name Alias: Opium
HEX Color: #997F7F
RGB Values: rgb(152, 126, 126)
cmyktool.com

FeSO_4

- Through the complex-forming metal salts, a bond is formed between the amide groups of the wool proteins and the dimers and trimers of the procyanidins. This causes a shift of the chemical bonds in the aromatic structure of the procyanidin, contributing to the color effect.
- Procyanidins affect the proportion of red to the overall color hue, which can be traced on the CMYK percentage scale. The alkaline-hydrolysis solution samples yielded colors composed of red with content above 50%.

Conclusions

- The red/red-brown color mentioned in the written sources from *P. erecta* and *R. acetosa* is obtained only under the influence of alkali as it was proven by practical dyeing experiments.
- Plants containing tannins may give a reddish-brown color under the influence of alkali, but it is still not bright red.
- Did the word "red" mean the same thing in the past as it does today?
- The main coloring compound in the roots of *Rumex acetosa* is procyanidin. Brighter colors can be obtained with an alkaline hydrolysis solution. Differences are in the composition of monomers, dimers and trimers.
- The range of reddish tones obtained from different plants containing tannins is similar.





Thank you for your attention!

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- LU-BA-ZG-2024/1-0007 Dyes and Dyeing: from Tradition to Industry

