

Supplementary Materials

Khipu Structure

1932.08.01

Table S1: Representation of khipu 1932.08.01 cord structure. The cord colour pattern “solid” refers to the visible colour pattern of the cord.

Pendant	S	ss	Material	Colour pattern	Pantone colour	Pantone colour	Pantone colour	Structure
1			cotton	solid	ivory			Z(2s)
1	1		cotton	solid	465			Z(2s)
1	1	1	cotton	solid	2311			Z(2s)
1	2		cotton	barber pole	468	5497		Z
1	3		cotton	mottled	7612	468		Z
1	4		cotton	mottled	464	468		Z
1	5		cotton	solid	ivory			Z
1	6		cotton	mottled	464	468		S(2z)
1	7		cotton	solid	468			Z(2s)
1	7	1	cotton	barber pole	466	464		Z(2s)
1	7	2	cotton	mottled	5497	468		S(2z)
1	7	3	cotton	mottled	7612	468		Z(2s)
1	8		cotton	solid	ivory			Z(2s)
2			cotton	solid	ivory			Z(2s)
2	1		cotton	mottled	467	465		Z(2s)
2	2		cotton	barber pole	468	5497		Z(2s)
2	3		cotton	mottled	7612	468		Z(2s)
2	4		cotton (ecru) and wool (red)	mottled	468	201		Z(2s)
2	5		cotton	solid	468			Z(2s)
2	6		cotton	mottled	464	468		Z(2s)
2	6	1	cotton	solid	ivory			Z(2s)
2	7		cotton	mottled	464	468		Z(2s)
2	8		cotton	solid?	468		464	Z(2s)
2	8	1	cotton	segmented wari	464	468		Z(2s)
2	8	2	cotton	mottled	5497	468		Z(2s)
2	8	3	cotton	mottled	7612	468		Z(2s)
2	9		cotton	solid	ivory			Z(2s)
2	9	1	cotton	segmented wari	464	468		Z(2s)
2	9	2	cotton	barber pole	5497	468		Z(2s)
2	9	3	cotton	mottled	7612	468		Z(2s)
3			cotton	solid	ivory			Z(2s)
4			cotton	solid	ivory			Z(2s)

*Structure “Z(2s)” indicates a cord that has a final “Z” ply composed by two “s” plies. Deeper levels of ply are not indicated because they could not be collected consistently. For some cords it was only possible to collect the final ply direction. For a detailed explanation of the parenthetical notation to register cord structure see [58]

1932.08.02

Table S2: Representation of khipu 1932.08.02 cord structure. The cord colour pattern "solid" refers to the visible colour pattern of the cord.

Pendant	S	ss	Material	Colour pattern	Pantone colour	Pantone colour	Pantone colour	Structure
1			cotton	solid	4685			Z(2s)
1	1		cotton	solid	465			Z(2s)
1	2		cotton	solid	ivory			Z(2s)
1	3		cotton	mottled	7613	4685		Z(2s)
1	4		cotton	mottled	465	443		Z(2s)
1	5		cotton (pink) and wool (red)	mottled	7613	201		Z(2s)
1	6		cotton	mottled	465	ivory	443	Z(2s)
1	6	1	cotton	segmented wari	ivory	7538		Z(2s)
1	7		cotton	solid	7538			Z(2s)
1	7	1	cotton	solid	7538			Z(2s)
1	8		cotton	solid	4685			Z(2s)
1	8	1	cotton	solid	465			Z(2s)
1	8	2	cotton	solid	ivory			Z(2s)
1	8	3	cotton (pink) and wool (red)	mottled	7613	201		Z(2s)
1	8	4	cotton	mottled	7613	ivory		Z(2s)
1	8	5	cotton	mottled	465	443		Z(2s)
1	8	6	cotton	segmented wari	ivory	7613		Z(2s)
1	8	7	cotton	mottled	465	443	ivory	Z(2s)
1	8	7	cotton	segmented wari	ivory	443		Z(2s)
1	8	8	cotton	mottled	ivory	463		Z(2s)
1	8	8	wool	solid	201			Z(2s)

*Structure "Z(2s)" indicates a cord that has a final "Z" ply composed by two "s" plies. Deeper levels of ply are not indicated because they could not be collected consistently. For a detailed explanation of the parenthetical notation to register cord structure see [58]

Samples

Table S3. Samples, colours and corresponding areas of wrapping on both khipus

Sample	Sample position	Colour	Corresponds to wrapping band on khipu (bold if included in XRF map <i>in situ</i>)	
			1932.08.0002	1932.08.0001
1	P _{1S8S5}	blue	P ₁ – Band 5, 6, 7 P_{1S8} – Band 1, 3, 5	P₁ – Band 3, 5, 6, 7 P _{1S8} – Band 1, 5 P ₂ – Band 3, 5, 6, 7 P_{2S9} – Band 1, 5 P ₃ – Band 3, 5, 6, 7 P ₄ – Band 3, 5, 6, 7
2	P _{1S8S4}	pink	P₁ – Band 1, 2, 3, 6	P₁ – Band 1

			P_{1S8} – Band 4	P ₂ – Band 1 P ₃ – Band 1 P ₄ – Band 1
3	P _{1S8S4}	ivory	P₁ – Band 2, 6 P_{1S8} – Band 4	P₁ – Band 1, 3, 6 P _{1S7} – Band 1, 3 P _{1S8} – Band 2, 4 P ₂ – Band 1, 3, 6 P_{2S8} – Band 1 P_{2S9} – Band 2, 4 P ₃ – Band 1, 3, 6 P ₄ – Band 1, 3, 6
4	P _{1S8S8}	brown	P_{1S8} – Band 1	
5	P _{1S8S4S1}	red	P ₁ – Band 4, 5, 8 P_{1S8} – Band 2, 6	P₁ – Band 4, 6, 8 P _{1S5} – Band 1 Knot 1 P ₂ – Band 4, 6, 8 P ₃ – Band 4, 6, 8 P ₄ – Band 4, 6, 8
6	P _{1S2}	ivory	P₁ – Band 2, 6 P_{1S8} – Band 4	P₁ – Band 1, 3, 6 P _{1S7} – Band 1, 3 P _{1S8} – Band 2, 4 P ₂ – Band 1, 3, 6 P_{2S8} – Band 1 P_{2S9} – Band 2, 4 P ₃ – Band 1, 3, 6 P ₄ – Band 1, 3, 6
7	P _{1S2}	ecru	\	\

Multiband imaging



Figure S1 Overview VIS image of Khipu 1932.08.0002

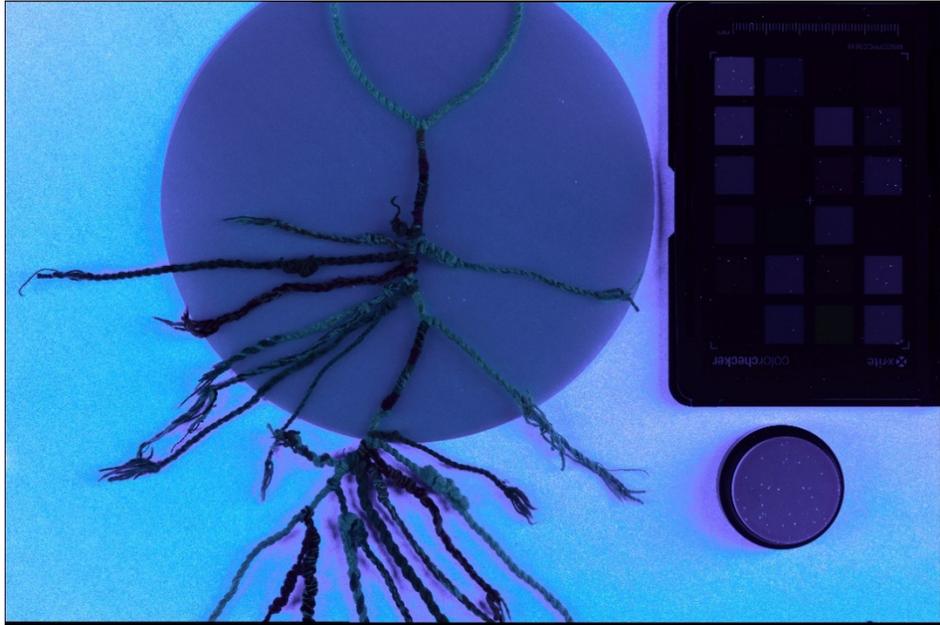


Figure S2. Overview UVL of Khipu 1932.08.0002



Figure S3. Overview VIS image of samples from the “Meaningful materials in the khipu code” project.

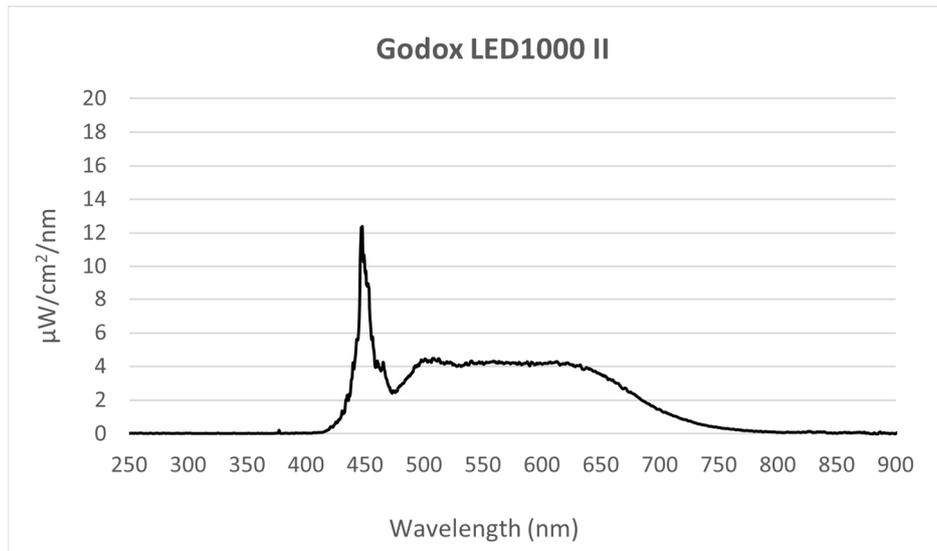


Figure S4. Irradiance of Godox LED 1000 II measured with an Ocean Optics Flame spectrometer at 100 cm distance.

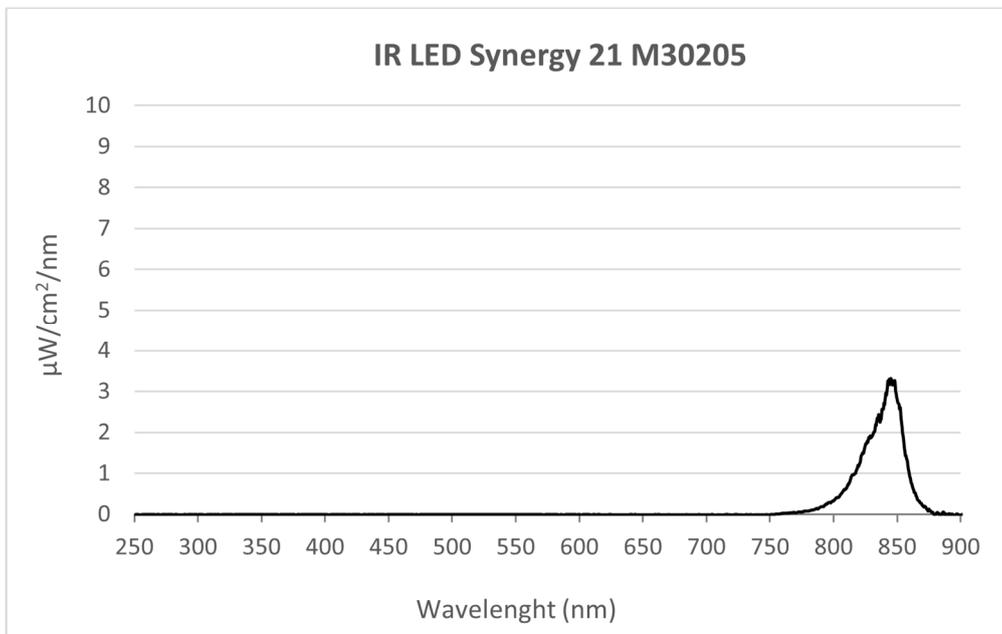


Figure S5. Irradiance of Godox LED 1000 II measured with an Ocean Optics Flame spectrometer at 100 cm.

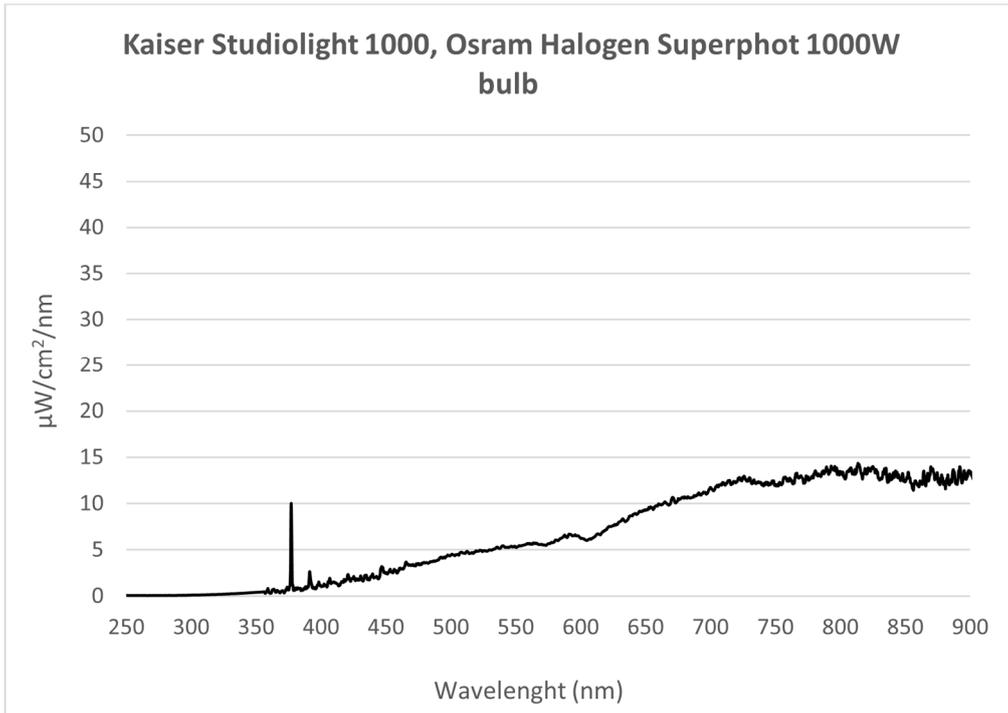


Figure S6. Irradiance of Kaiser Studioliight 1000 fitted with an Osram Halogen Superphot 1000W bulb measured with an Ocean Optics Flame spectrometer at 100 cm.

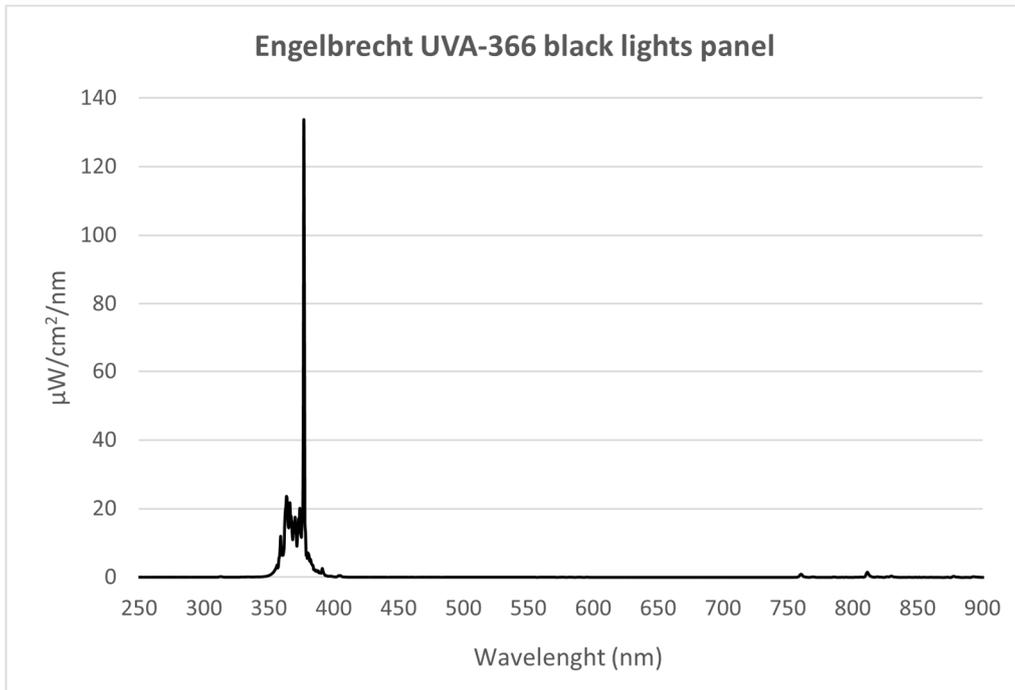


Figure S7. Irradiance of Engelbrecht UVA-366 black lights measured with an Ocean Optics Flame spectrometer at 100 cm.

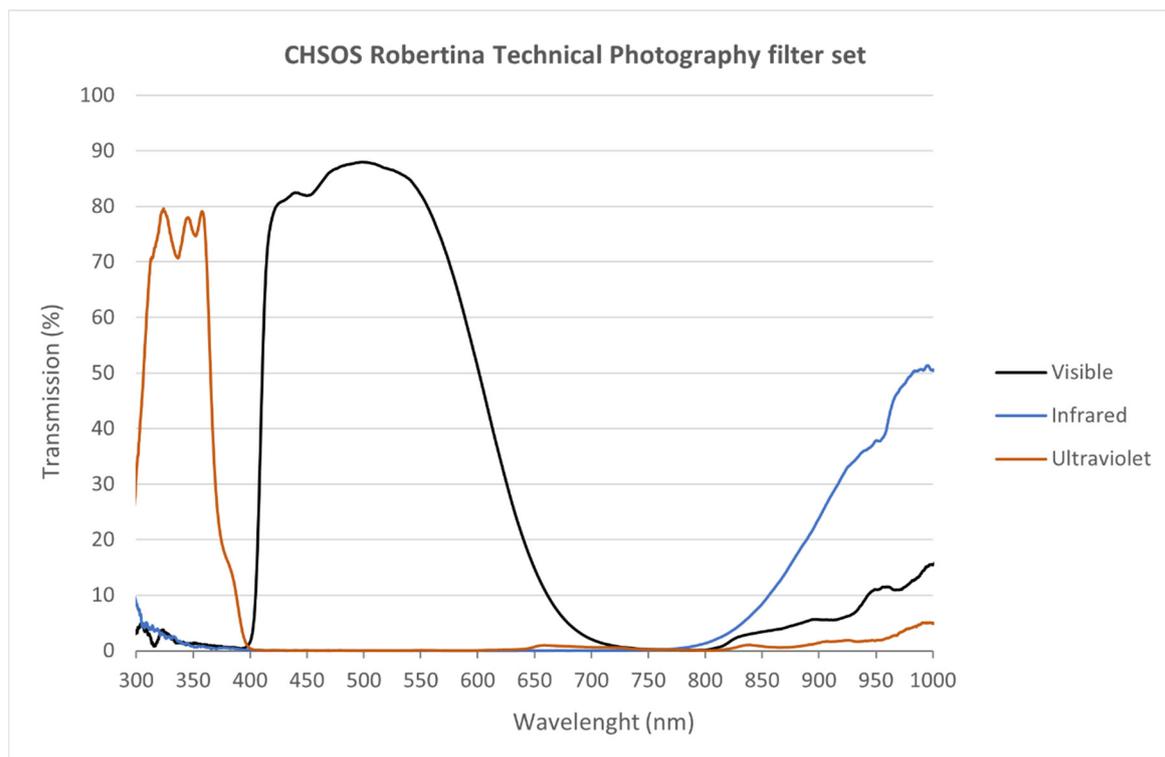
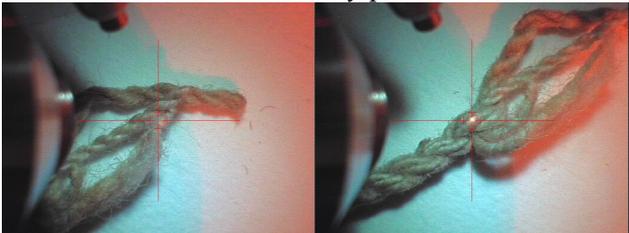


Figure S8. Transmission of CHSOS Robertina Technical Photography filter set [32]

XRF

Table S4. XRF positions and measurement details. A PDF report of all results is available from Zenodo [<https://doi.org/10.5281/zenodo.7387415>].

XRF positions 1932.08.0001	Instrument settings	Comment
P ₁ multicoloured wrapping band 1-6 map 	Live time: 10 s Length 22.95 mm Width 1.00 mm Area 22.72 mm ² Spot distance 0.09 mm Measurements 3072 Time for scan 13:39 h	9 outliers with high levels of zinc, iron or copper were removed.
P _{1S3} ivory-pink cord map 	Live time: 10 s Length 1.30 mm Width 1.49 mm Area 1.82 mm ² Spot distance 0.10 mm Measurements 210 Time for scan 0:56 h	Uneven surface resulted in map with higher intensity on one end.
P _{1S3} ivory-pink points 	Point analyses: 3 points on ivory threads and 3 points on pink threads Live time: 30 s	

<p>P_{2s2} blue-ecru cord map</p> 	<p>Live time: 10 s Length 4.14 mm Width 0.40 mm Area 1.49 mm² Spot distance 0.09 mm Measurements 235 Time for scan 1:02 h</p>	
<p>P_{2s8} ivory-pink wrapping map</p> 	<p>Live time: 10 s Length 11.79 mm Width 2.0 mm Area 23.34 mm² Spot distance 0.09 mm Measurements 3036 Time for scan 13:29 h</p>	<p>Faulty motor movement caused slanted map</p>
<p>P_{2s9} blue-ivory-pink wrapping map</p> 	<p>Live time: 10 s Length 6.80 mm Width 0.50 mm Area 3.4 mm² Spot distance 0.10 mm Measurements 414 Time for scan 1:50 h</p>	<p>Faulty motor movement and uneven area resulted in a map largely out of focus.</p>
<p>XRF positions 1932.08.0002</p>	<p>Instrument settings</p>	<p>Comment</p>
<p>P_{1s8} multicoloured wrapping map</p> 	<p>Live time: 10 s Length 0.90 mm Width 24.00 mm Area 21.60 mm² Spot distance 0.10 mm Measurements 2410 Time for scan 10:42 h</p>	<p>3 outliers with high levels of zinc, iron or copper were removed.</p>
<p>P₁ pink-mottled wrapping map</p> 	<p>Live time: 10 s Length 5.00 mm Width 1.00 mm Area 5.00 mm² Spot distance 0.10 mm Measurements 561 Time for scan 2:29 h</p>	
<p>P_{1s2} ecru-ivory points</p> 	<p>Point analyses: 3 points on ivory threads and 3 points on coloured threads Live time: 10 s</p>	<p>Point colour 1 missed the thread and resulted in a spectrum of the paper background.</p>

HPLC-HRMS

Sample treatment

A mild extraction by dimethylformamide (DMF) and 0.1% Na₂EDTA 1:1 (v/v) was applied to the micro-samples to extract the colored compounds present in the textiles studied. In detail, 200 μ L of solution were added to the sample; extraction was performed at 60 °C for 60 min in ultrasonic bath. The supernatant was filtered with PTFE filters (0.45 μ m) and injected in the chromatographic system.

Chemicals

For sample treatment, ethylenediaminetetraacetic acid disodium salt (Na₂EDTA, Fluka, USA) and dimethyl formamide (DMF, 99.8% purity, J.T. Baker, USA) were used as received.

The eluents used for the HPLC-ESI-Q-ToF analyses were water and acetonitrile, both LC-MS grade (Sigma-Aldrich, USA). All eluents were added with 0.1% v/v formic acid (FA; 98% purity, J.T. Baker, USA).

Results

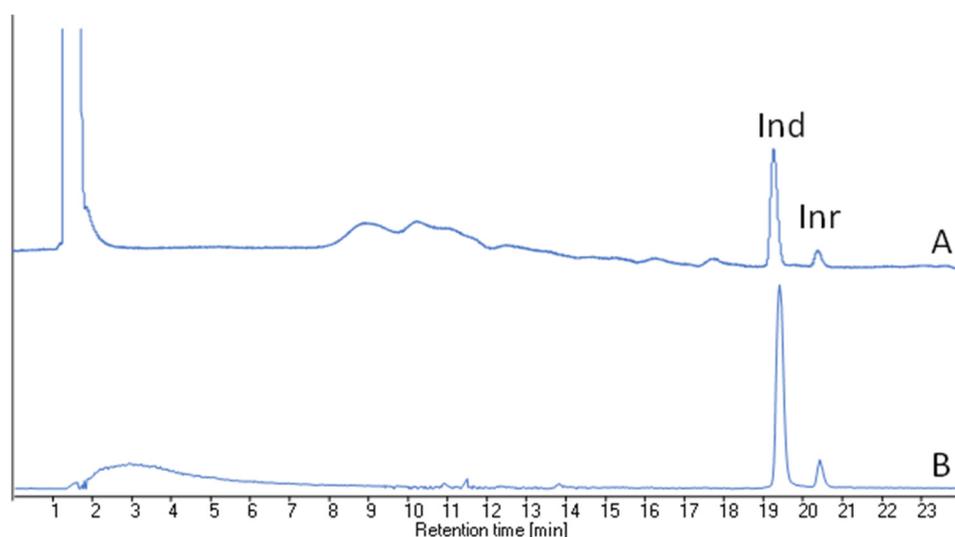


Figure S9. Chromatograms obtained for the extract of sample 1. A: HPLC-DAD chromatogram extracted at the maximum absorbance value in the range 550-650 nm; B: HPLC(+)-ESI Extracted Ion Chromatogram corresponding to the molecular ion of indigotin (Ind) and indirubin (Inr).

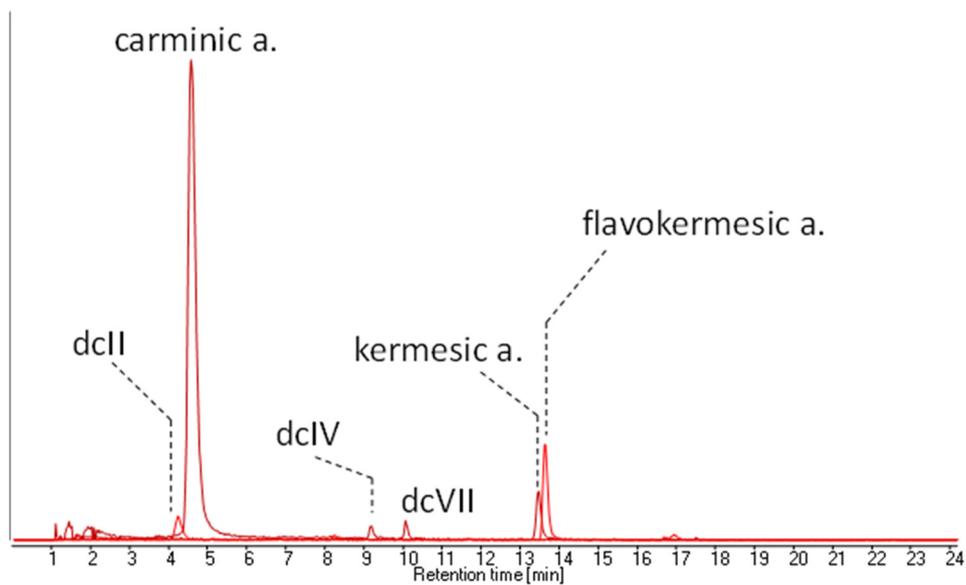


Figure S10. Chromatograms obtained for the extract of sample 2. HPLC(-)ESI Extracted Ion Chromatograms corresponding to the molecular ions of carminic, kermesic and flavokermesic acids, and the *Dactylopius coccus* markers dclI, dclIV and dcVII.

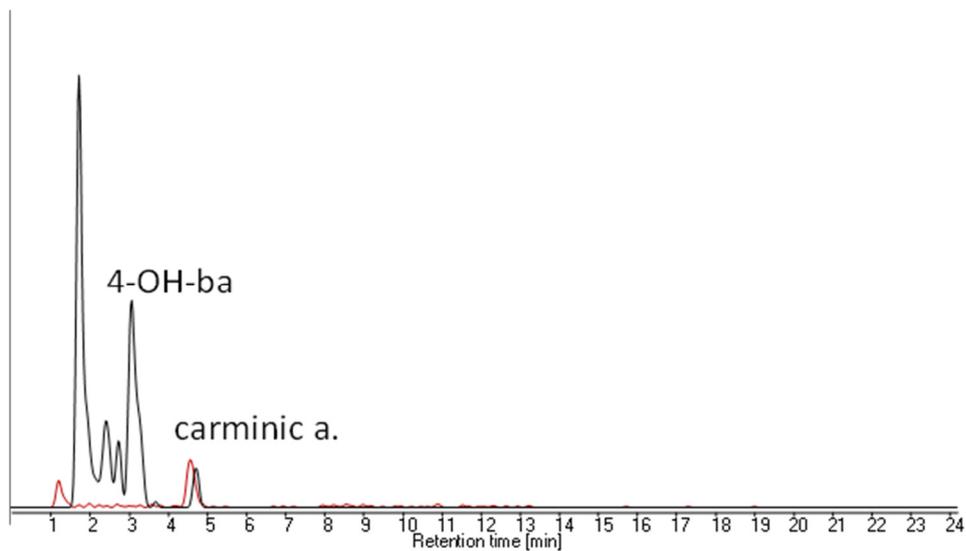


Figure S11. Chromatograms obtained for the extract of sample 4. HPLC(-)ESI Extracted Ion Chromatograms corresponding to the molecular ions of carminic acid and 4-hydroxybenzoic acid (4-OH-ba).

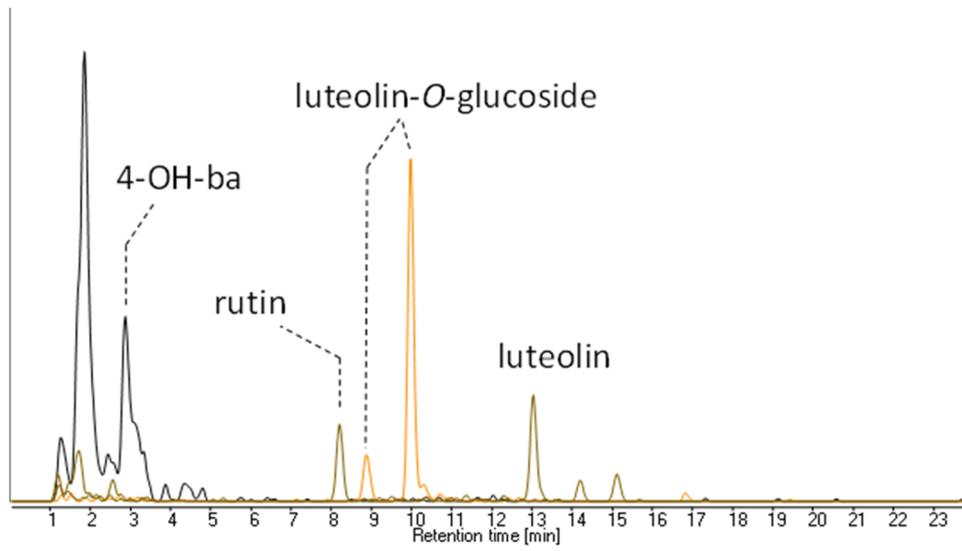


Figure S12. Chromatograms obtained for the extract of sample 7. HPLC(-)ESI Extracted Ion Chromatograms corresponding to the molecular ions of rutin, luteolin-O-glucoside, luteolin, and 4-hydroxybenzoic acid (4-OH-ba).