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Introduction

The identification of dyes and pigments is nowadays very precise by means of different systems of chromatographic analysis. Nevertheless, as the same dye component can be found in different plants and animals, it is important when studying dyes in textiles to consider the geographical and cultural context of both the textile and the possible dyestuffs used historically in the area.

In the case of South American textiles, the major source of bibliographical information about the subject can be found in the Spanish Chronicles from the Americas, produced during the XVI–XVII centuries. Although European textile technology was introduced in the New World soon after the arrival of the Spaniards, it can be easily accepted that the descriptions about indigenous dyeing procedures gathered in the chronicles generally refer to genuinely autochthonous practices. When the botanists of the Spanish scientific expeditions to South America in the XVIII century, later reported about the plants used by local dyers of Peru and Colombia, those happened to be the same as the ones mentioned in the previous centuries. Furthermore, ethno-botanical data gathered by Francis MacBride in his *Flora of Peru*[1], during the first half of the twentieth century, again coincide with preceding information. Finally, ethnographic field research conducted by the author between 1986-1992 with dyers of Indian Communities of Ecuador and Peru for the study and register of dyeing techniques and common names of the plants, gave similar results[2].

Red Dyes from the Andean Region

He wore his "llauto" red, and the feather of his parasol and his shirt red… and the underwear was red, and his cape light red… (Guamán Poma de Ayala)

When the chronicler Guamán Poma de Ayala described in 1613 the clothing of nobleman Cinchi Roga Inga[3] he seemed to be remarking on the particular significance of red colour in Inca society. In fact, red colour, in various shades, is profusely found in archaeological and ancient textiles from South America.

Dactylopius coccus Costa, Common Quechua name: macnu

Most of the crimson, scarlet and purple hues that we can observe in old Andean textiles came from one single source: cochineal *(Datylopius* spp.*).* These parasitic insects grow wild or domesticated, on several species of *Opuntia* cactus. The insect was named *macnu* or *magno* in the Quechua language. Such was the importance of this commodity that Inca ruler's regulations considered its storage in the royal warehouse as a first necessity, comparable to

[1] MacBride, J. Francis (1946 – 1960)
[2] Roquero, Ana: *Tintes y Tintoreros de America - Catálogo de materias primas y registro etnográfico de México, Centro América, Andes Centrales y Selva Amazónica*, Instituto del patrimonio Histórico Español, Ministerio de Cultura, Madrid 2006.
[3] Guamán Poma de Ayala (1987:A82)

food: …*we order that in the entire kingdom there must be food in abundance… and magno… and other kinds of leaves to dye colours for cumbi…*[4].

Figure 1. *Cochineal (Dactylopius coccus), Mexico. Photo: A. Roquero.*

Up to 95% of the colouring components of cochineal dye correspond to carminic acid, of the anthraquinone group. The average of the rest of its components, according to HPLC analysis carried out by Wouters and Verhecken on extracts from dried insects is: 0.1% = kermesic acid, 0.4% = flavokermesic acid, the rest belonging to four other colorants of unknown structure. Nevertheless, analysis carried out on fibres dyed with cochineal previously mordanted with alum, tin, iron and copper showed different proportions of the colouring components due to the selective absorption of the colouring substances by the fibres[5].

All these compounds are responsible for the characteristic crimson hue of the dye. But the original crimson colour can be modified by combination with different metals or by changing the pH of the dye bath. A bright scarlet can be obtained by adding tin salts or an acid product, or a deep purple may be achieved by adding an alkaline product or an iron compound.

An excellent example of the use of colour modifiers was found by the author among *Salasaca* dyers from Tungurahua, in Ecuador. Women of the community wear a rectangular, hand-woven, woollen garment over the shoulders. This garment receives in Spanish the name of

[4] Guamán Poma de Ayala (1987:A184)
[5] Cardon (2007:624)

vara y media in reference to the length of the cloth[6]. It was traditionally dyed with cochineal[7] but each woman would choose a different shade of red.

Figure 2. *Salasaca dyer showing red woollen cloths with modified cochineal red colours. Ecuador. Photo: A. Roquero.*

Salasaca dyers collect wild cochineal –probably *Datylopius confussus*– which they crush to form cakes that are left to dry for future use. When they have to dye, they collect *tiri* leaves (*Miconia* sp.) which, as Francisco Hernández observed in 1571, *prepare and improve the little worms* (cochineal) *that dye scarlet*[8]. The leaves of *Miconia* spp. contain aluminium and tannins and serve therefore as an excellent mordant. First the leaves are boiled, then the cochineal cakes are dissolved in the bath and finally three wetted woollen lengths of cloth are introduced. Once the dye is finished, the cloths, which present a crimson colour, are taken out and set apart while the dyer puts the juice of 30 lemons[9] in the pot and mixes it carefully. One piece of cloth is returned into the dye pot and left for a short while. When this piece is taken out it shows a bright scarlet hue. A second piece of dyed cloth, still wet, is thoroughly rubbed with wood ashes until it takes a purple colour. The third one is left in its original crimson hue, a process that is not difficult to imagine done by Pre-Columbian dyers.

Other Red Dyes Found in Andean textiles

In spite of the evident superiority and versatility of cochineal, other sources of red and purple dyes were reported by the chroniclers in South America. The following have been used since Pre-Columbian times as has been made evident by analysis in Andean textiles.

Relbunium hypocarpium (L.) Hemsl. ssp. *hypocarpium* [=*Galium hypocarpium* (L.) Endlicher ex Griesbach], Common Quechua name: chamiri

[6] *Vara*: old Spanish measure = 83'5 cm. The Salasaca garment measures one *vara* and a half = approximately 125 cm.

[7] Actually, some women wear garments of colours different to red, dyed with synthetic products.

[8] Hernández (1959:II,118)

[9] Probably in pre Columbian times, when lemons had not yet been introduced in the Continent, they used *Oxalis* spp. leaves to acidify the dye bath. The plant is mentioned by Guamán Poma de Ayala among those kept in the Inca warehouse for dyeing purposes.

Relbunium croceum ssp. *involucratum* (H.B.K.) Ehrendf. (= *R. ciliatum* Hemsl. = *R. corymbosum* R.&P.), Common Quechua names: antaco, chapi-chapi, ccallo-huacta

A strong red, slightly orange, is produced by the roots of several herbs of the *Relbunium* and *Galium* genus from the *Rubiaceae* family. These grow in tropical forests of the Continent at medium and high altitudes, between 900 and 3000 m. The colorants they contain belong to the anthraquinone group and therefore provide very fast colours. Bernabé Cobo, in 1653, described *chapi-chapi,* as *a small plant which produces short slender stems that lie on the ground; with many little leaves…* and indicates that *the natives use them to dye the red woollen cloth*[10].

Figure 3. "*Relbunium" sp. Cotopaxi, Ecuador. Photo: A. Roquero.*

Recent analysis of colorants on *Relbunium* species carried out by C. Duta Moresi[11] indicate as the most remarkable point the complete absence of alizarin in all the samples analyzed. This characteristic makes the species distinct from other *Rubiaceae.* In the case of *Relbunium hypocarpium*, the red dye is characterised by the predominance of purpurin, accompanied by lucidin and/or xanthopurpurin, pseudopurpurin, munjistin, and an unknown anthraquinone[12].

Arrabidaea chica (Humb. & Bonpl.) Verlot [= *Bignonia chica* H.&B.]
Common names: chica (Colombia), carajurú (Brazil), puca ponga (Peru)
The sap from chica bark, stems, and leaves was popularly used in tropical America to paint the face and body red. Archaeological evidence shows that it was also an important red dye for textiles in the past. *Arrabidaea chica* is a climbing plant that grows in tropical forests of the Continent, between sea level and 1500 m. and sometimes at higher levels, up to 2600 m in Peru, near Cuzco[13].

[10] Bernabé Cobo (1964:189)
[11] Duta Moresi (1999)
[12] Cardon (2007:263-64)
[13] Cardon (2007:260)

Figure 4. "*Arrabidaea chica." Colombia. Photo: B. Devia.*

Investigation and analysis by HPLC-PDA carried on by Devia[14] *et al.* on textiles from the tenth to the sixteenth centuries, belonging to Muisca, Guane and U'wa civilisations from Colombia, revealed the recurrent presence of this red dye in textiles of the area. The main dye constituent of *Arrabidaea,* carajurin, was established by Chapman *et al.* in 1927, for which they proposed a 3-desoxyanthocyanidin structure. Recent research by Devia *et al.* has confirmed the structure proposed by Chapman for carajurin, and have isolated and determined the structure of two new 3-desoxyanthocyanidins from the leaves, all of which produce fairly stable red dyes[15].

Other Red Dyes to Look for in Andean Textiles

Chronicles of Peru mention dyestuffs that can not be obtained in the highlands but might have been used in cultural areas of the coast, or imported to the sierra from the eastern lowlands.

Haematoxylon brasiletto Karsten, Common name: Brazilwood

Such is the case of brazilwood. Bernabé Cobo mentioned in 1653: *The Indians from Cuzco call yunca the lands that lie at the eastern part of the mountain chain… there grow infinite trees of precious woods, such as brazil…*[16]. The name of brazil is usually given to *Caesalpinia echinata* and other *Caesalpinia* species as well as to *Haematoxylon brasiletto,* but the wood of other trees belonging to different species, genus and even families, was sometimes also named brazil just because it yielded a red dye. It is not possible, therefore, to know exactly about which plant the chronicler is talking. Geographical distribution does not indicate proximity of any of them to the main cultural centres in the Andean region although *Haematoxylon brasiletto* can be found in South America in dry areas of Venezuela and Colombia from sea level up to 1200 m, and its wood might have been object of trade. The colorant obtained from brazilwood, brazilein, belongs to the group of homoisoflavonoids. It is not remarkable for its fastness but imparts a bright red that can eventually be modified into purple in an alkaline medium.

[14] Devia (2002 and 2003)
[15] Cardon (2007:261-62)
[16] Cobo (1964:t. I, 67-69)

Figure 5. *"Haematoxylon brasiletto." Costa Rica. Photo: A. Roquero.*

<u>*Bixa orellana* L., Common Quechua name: huantura</u>

This small tree grows in tropical and sub tropical areas of the Continent. The pulp that covers the seeds contains bixin, norbixin, and six other colorants of the carotenoid family, as well as tannins[17]. The orange-red paste obtained from huantura seeds was used to paint face and body, as well as for food flavouring. However, bibliographical information of its use as a dye is very scarce. Only Bernabé Cobo, in 1653 makes an eloquent observation about its dyeing properties: *This colour is so firm, that even with soap and lye it is impossible to clean the cloth dyed with it*[18]. Cobo's remark seems exaggerated, so perhaps he just refers to stained cloth, not dyed on purpose. Anyhow it indicates its possible use as a dye in America, maybe not for its fastness but because of its beauty. Such was the reason of its great success among silk European dyers in the XVIII century[19].

Figure 6. *"Bixa orellana." Peru. Photo: A. Roquero.*

Tannins for Russet

A remark made in 1525 by Gonzalo Fernández de Oviedo leads us to consider that further analysis in search of condensed tannins in pre Columbian textiles as a source of red would be interesting. The chronicler said: *Indians call this tree nanci. This tree is like the one of brazilwood, but it is not the same brazil, as some think…*[20]. He refers to *Byrsonyma crassifolia,* known as indano in Peru. It belongs to the *Malpighiaceae* family and it is impossible to mistake it with either *Haematoxylon brasiletto* or with any species of *Caesalpinia.*

[17] Mayer (1950:84-92)
[18] Cobo (1964:I, 254-255)
[19] Roquero (2006:83-84)
[20] Fernández de Oviedo (1992:I, 295), Soukup (no date.:94)

Byrsonyma crassifolia H.B.K., Indano, nanci, nanche
Alnus jorullensis H.B.K., Lambrán

The bark of indano contains condensed tannins that are transformed by oxidation into strong russet dyes of the phlobaphene type. The same kind of tannins and other pigments of the anthracenic group, like emodin, are also present in the bark of alder trees (*Alnus* spp.)[21]. The use of alder bark to obtain a rusty red colour is common in Central and South America. The same type of bright orange-red, tannin dyes, developed by oxidation on cotton cloth, are still achieved, by Shippibo dyers in the Peruvian Amazon using mahogany bark (*Swietenia macrophylla*) and by dyers living near mangrove swamps with mangrove (*Rhizophora mangle*) root barks[22]. Although this type of dyes is especially suitable for cotton, the author has found dyers in Cuzco and in the Parobamba region in Peru using them for wool and alpaca.

Figure 7. *"Byrsonima crassifolia." El Salvador. Photo: A. Roquero.*

Purple Dyes to Look for in Andean Textiles

Purple hues often found in Peruvian textiles were not always obtained by modifying cochineal crimson with alkaline products: some were dyed with true shellfish purple. Besides, purple being universally considered the most precious of dyes, has been historically imitated with cheaper dyestuffs, among which orchil producing lichens which yield luminous violet, mauve and strong pink colours were the best alternative. Therefore, both molluscs and lichens need to be contemplated when studying South American textiles. The difference between both sources of purple is their fastness. Purple dye obtained from different marine molluscs of the *Muricidae* family, is an indigoid of excellent fastness while orchil is extremely fugitive.

The majority of references about purple in South American dyeing point to the Guayaquil province in Ecuador. By the end of the XVIII century Antonio de Alcedo writes: … *the cotton thread spun in the Guayaquil province… they dye it in a bright purple permanent colour, by no other means than wetting it in the juice that expels a sea snail that can be found on those beaches*[23].

Several species of purple-producing molluscs were available to pre-Columbian dyers in the Pacific coasts of South America: *Plicopurpura pansa* (Gould, 1853), distributed from Baja California to as far south as Ecuador; *Thais kioskiforme* (Duclos 1832), from Baja California to North of Peru and *Concholepas concholepas* (Bruguière 1758) from Peru to Patagonia.

[21] Font Quer (1978:100) / (1985:72)
[22] Roquero (1997:50-57)
[23] Alcedo (1967:315)

The use of purple dye in pre-Columbian times was confirmed for the first time by chromatographic analysis in 1962. Analysis was carried out at Harmon Colours Laboratory, National Aniline Division, Allied Chemical Corporation, from a selection of ancient Peruvian textiles[24]. The main component of oxidised purple dye is 6,6'-dibromoindigotin, and may include–depending on the species – 6,6'-dibromoindirubin, indirubin and, in some cases, traces of isatin[25].

Roccella portentosa (Mont.) Larb. and *Roccella* spp. Commercial name: "Lima weed"
There is no written record of the use of lichens for dyeing in ancient Peru. In contrast, the trade of orchil-producing lichens is reported in the documents of British companies which, in the XIX century, exported hundreds of tons of the so called "Lima weed" (lichens of the *Roccella* genus) from Peru and Chile to England[26].

Parmelia spp. Common Quechua names: rumi-unku and llast'a llast'a
The author has found ethnographic examples of red lichen dyeing performed by dyers in villages near Cuzco, and in the Parobamba district, in Peru. They use foliose lichens of *Parmelia* species, which form dense clusters in Peruvian highlands. These lichens contain orcinol, a red-purple pigment, and usneic acid, a yellow one. Dyers obtain a russet red from them.

Popular Red and Purple Dyes
Many other red and purple dyestuffs can be obtained in the area for which there is no historical record regarding use or trade. But we do have reliable ethnographic data. Most of these dyes are extracted from fruits, and the colorants they contain belong to the anthocyanidin type, so they are not very fast. Women use them, especially for small items that are not meant to last. For example fruits of *Monnina* spp. and *Coriaria thymifolia* that yield a luminous bluish purple are used for bag strings and hair ribbons. For a bright cherry colour, the use of airampo fruits (*Phytolacca* spp.) is popular from Mexico to Peru. And red figs of airambo, *Opuntia soehrensii*, are used to dye the underskirts of wedding dresses in a bright scarlet.

Saving Cochineal?
It seems especially interesting the practice of mixing certain red or purplish dyestuffs, such as purple corn grains or *Miconia* spp. fruits, with cochineal.

Zea mays L. Common Quechua names: muti, sara
Miconia spp. Common Quechua name: mutti mutti
Both stuffs are used nowadays by Cuzco dyers together with cochineal to obtain red and purple. Perhaps, like nowadays, those cheap, not very fast dyes, were sometimes used to save the expensive cochineal. Therefore, when analysing the colouring substances of an Andean textile, it may also be worth considering these popular sources of red dyes.

[24] Born in: Turok (1988:21)
[25] Cardon (2007:556)
[26] Investigator Isabella Whitworth (Devon, G.B.) studies the actual documents of a XIX century British firm specialised in the import of "Lima weed" for the dye industry.

Figure 8 (left). *Purple corn, "Zea mays." Peru. Photo: A. Roquero.*
Figure 9 (right). *Reference samples of dyes mentioned in this paper. Photo: A. Roquero.*

Essay of Analysis on Ethnographic Dyes

Various analyses on red Peruvian dyes were done previously to this presentation at the Spanish Institute for Cultural Heritage (IPCE) laboratory[27]. As expected, the results obtained for the fibres dyed with *Dactylopius coccus* and *Relbunium* species indicated that the main components are carminic acid and purpurin, respectively. Therefore, the principal objective was to characterise the main components present in red dyestuffs from the Andean Region which had not yet been identified.

The sample chosen in this occasion was wool dyed in bright red with chile-chile (*Geranium filipes* Killip) by a craftsman of Pitumarca, near Cuzco (Peru). Chile-chile is an endemic herb from the Andean Region, growing at altitudes about 3000 – 4500 m. above sea level. The part of the plant used was the root and alum was employed as mordant. Analysis was performed using HPLC-DAD system.

Results and discussion

Three compounds were detected as main components in the *Geranium filipes* sample. As shown in Figure 10, the UV-visible absorption properties (λ_{max}) are similar for the three and typical for anthocyanin dyes.

Figure 12

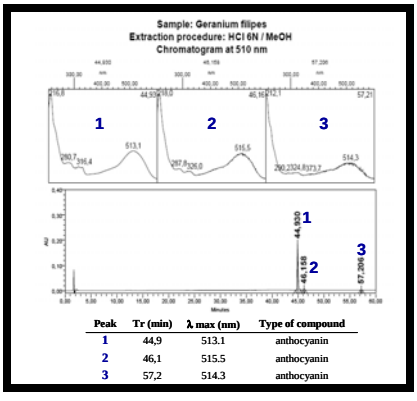

Figure 10 (left). "*Geranium filipes" sample. Photo: A. Roquero.*
Figure 11 (right). *Chromatogram at 510 nm of fiber sample dyed with "Geranium filipes" obtained by HPLC-PDA.*

[27] All samples were obtained by the author from a reference collection belonging to the IPCE, in particular from those included in the project "Dyes and Dyers from the Americas".

Their absolute identification results difficult due to the unavailability of individual standards of anthocyanins in the IPCE laboratory and the fact that UV-vis spectra of compounds with related structures are relatively similar. Further investigation, based on the presented preliminary study, will be focused on the individual identification of all components present in this and other similar endemic dyestuffs from America.

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