ANNATTO AND TURMERIC IN SPANISH 18TH CENTURY FABRICS: IDENTIFICATION AND OPTIMISATION OF DYEING TECHNIQUES

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ABSTRACT: *Yellow and orange colourants obtained from annatto seeds and turmeric rhizomes were commonly used in silk dyeing in Spain in the 18th century. Their optimisation, the knowledge from the results of their different dyes, as well as their principle characteristics, are greatly important to know and understand the worked silk textiles produced in Spain during this period.*

KEYWORDS: natural dyes, annatto, turmeric, silk, textile dyeing, Spanish fabrics

1. INTRODUCTION

The textiles produced in Spain, above all, Valencian brocaded textiles from the 17th and 18th centuries, never fail to amaze us for their chromatic richness, the range of shades combined with exceptional mastery, and their motifs and designs, most of which accurately represent the typical flora of the region.

The art of silk dyeing in Spain, as explained by Luis Fernández, master silk dyer from the Royal Silk Factory of Valencia, required a very extensive range of colours and shades (Fernández, 1995:39). This situation forced dyers to be constantly on the lookout for and in search of new colours. For this reason, the use of a huge variety of dyes and the constant search for new mixtures and methods were necessary to achieve the brightest and most precious shades of fabric so that they would always be attractive to the consumers' eyes at that time.

2. SUBJECT

This study focuses on turmeric and annatto. These two natural dyes, especially annatto, were widely used by dyers in Spain during this period as a pure component or in mixtures with other dyes. These practices resulted in a large variety of colours and shades which, according to dyers' documents from the period, were of the most varied shades and highly valued.

This study aims to show the results of the optimisation of these two natural colourants, which range from the extraction of their dyeing components to the preparation of the dye baths, by reproducing the primitive techniques described in dyers' documents and treatises on dyeing. It is important to point out that the book "*Instructive and practical treatise on the art of dyeing*", from 1778 and the "*Dissertation on the true causes preventing the perfection of good silk colours*" written in 1785 by Luís Fernández, were the main references on the reproduction of the dyes.

3. HISTORY

The silks produced in Valencia during this period, identified by their floral motifs and sufficiently vibrant and peculiar colours, were worked with dyed threads in a wide variety of natural colours, some from the East, such as turmeric and indigo, and others from the New World (America), like annatto, brazilwood, logwood and others.

Annatto and turmeric are two substantial colourants, dyes which allow a direct use as they do not require the action of a mordant or other chemical agents to set the dyeing component in textile fibres. The colourant components react and set into the fibres irrespectively of the action of a fixer. Among these dyes, the yellows and oranges from the annatto – *Bixa orellana L.* – plant, whose seeds release a golden orange dye, and the very intense yellow colourant extracted from the rhizome of the turmeric plant – *Cúrcuma longa L.* – are worth highlighting. Each dye reacts differently on each textile fibre, thus producing different shades of a greater or lesser intensity.

During the 18th century, colourants were classified according to their characteristics and qualities, and separated into two groups. The first group included the colourants considered *permanent or good dyes*, while the second group included those considered *fugitive or false dyes*. The latter type were generally used as a load for dyes *to achieve certain shades or to lower their cost. At times they were used alone; however, these dyes are considered of a very poor quality.* (Roquero, 2006:129).

Both annatto and turmeric were classified as belonging to the group of fugitive dyes. With regard to annatto, in his treatise,

Figure 1. Brocaded, worked silk – Valencia, 17th century

Figure 2. Achiote shrub

	Constructional parameters of the test fabric.								
	Name	Composition	Weave	Supplier	Reference	Warp-weft density (threads)		Fabric grammage	Fabric tickness
						Warp	Weft		
1 cm	Ponge 10	100% silk	Taffeta	Sodintex S. L.	Ref.. 2010	60	40	44,88 gr/m^2	0,175 mm

Table 1. Parameters of the tested fabric

chemist-dyer, Pierre Joseph Macquer, admitted that his colours were not absolutely solid and that they changed and deteriorated very easily. On the other hand, in the same article, he added that, "the colours produced by Annatto are so beautiful, that this alone is reason enough to use it, because with silk dyeing, beauty is always preferred over duration." (Macquer,1771:107).

Indeed, the orange and yellow shades resulting from the annatto seeds are of an extraordinary beauty. For this reason alone, the colourant, in spite of it being classified as a fugitive dye, was used for such a long time in the dyeing of silk in Spain as it produced magnificent colours, like those observed in the worked silk textiles produced in Spain during the 18th century.

Treatises on dyeing from the 18th century provide accounts of the huge variety of possible colours from the annatto seed as a result of the applying colourant alone at different concentrations, or mixed with other colourants or ingredients to produce colours such as "*golds, purples, maroons, golden browns, bright reds, reddish browns, tobacco colours, greens*", among others (Fernández, 1995:31-33.). These shades were frequently present in the treatises and documents of this period.

With regard to the colourant from the turmeric rhizome, Jean Hellot made some recommendations in his treatise on dyeing wools. To the colourant, he attributed characteristics that were not indicated for a good dyeing of this type of fibre. Hellot indicated that turmeric was, in some cases, used in the good dye as the basis for the appreciation and enrichment of yellows and greens as it bestowed them a greater density. On other occasions, it was used to give a golden hue to the golden yellows of the dyer's greenweed, or to tone down or lighten scarlet reds to make them a more orange colour. (Hellot, 1752:451-453). As for this procedure, the dyer next pointed out that "*this practice is prohibited because the air soon removes part of the colour from the turmeric, in such a way that the golden straw colours return to their first state, and scarlets darken considerably.*" (Hellot, 1752:452).

On the other hand, master dyer, Luís Fernández, make completely opposing recommendations in his treatise in relation to the use of turmeric. These circumstances have led one to believe that it was not the same colourant cited by Jean Hellot when he stated that, "*All of the colours in this Treatise can be dyed, colourfast and permanent, using turmeric. However, after dyeing and making alterations to the samples, they must be treated with lemon or vinegar to complete the dyeing process...*" (Fernández, 1995:105).

These two colourants were commonly used in Spanish dyes during the 18th century. They were used separately to produce shades of different colours, depending on the concentrations of the baths, and were also mixed with each other and with other natural dyes. The result is an endless list of colours present in the worked silk textiles produced in Spain during this period

4. EXPERMIENTAL

4.1. Reference Materials

Fabric:

For the study into dyes, one 100% silk fabric with taffeta interlacing was used, commercially known as Ponge, which was supplied by Sodintex, S.L. http://www.sodintex.com. Ponge is a fabric of Chinese or Japanese origin, composed of warp threads and grege silk grain and taffeta interlacing. Its name is derived from Pongée, the French name for the fabric.

Colourants:

Annatto seeds (ref. 37350 - C.I. Natural Orange 4) and turmeric roots (ref. 37230 - C.I. Natural Yellow 3) the colourants used in the study into dyes were acquired from Kremer Pigments.

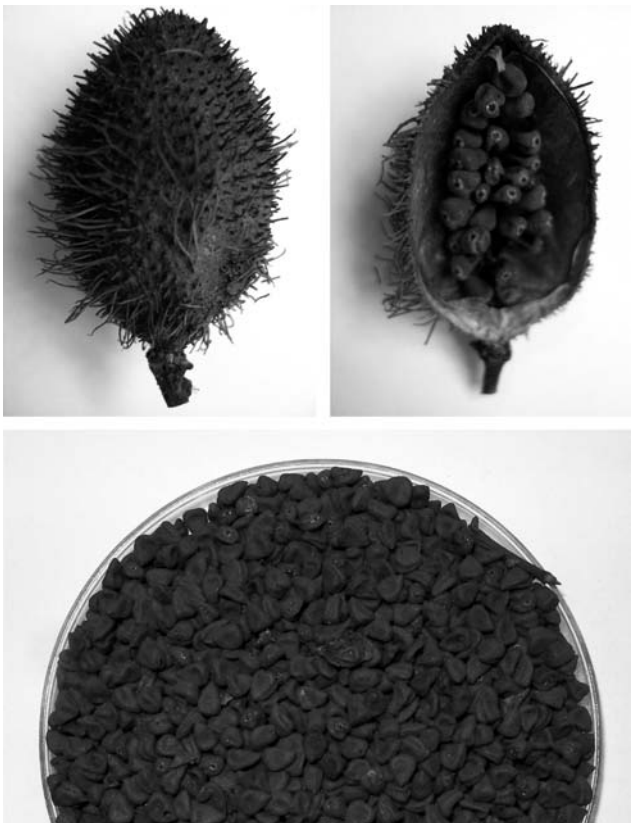


Figure 3. Fruit and seeds from the Annatto

Figure 4. Fruit and seeds from the Annatto

4.2. Optimisation of the dyes

Annatto

Annatto- *Bixa orellana L*. is a shrub of the *Bichaceae* family which reaches an approximate height of 3-6 m and whose seeds provide a highly valued colour dye which ranges from yellow-gold to brick red (Figure 2). It has a distinct smell and a characteristic taste, and was widely used to dye textile fibres in primitive villages throughout Central and South America. It has been used for silk dyeing in Europe since the 17th century (Cardon: 2003:245). Its hermaphrodite, pink flowers are arranged in corymbs with two to four flowers, each with numerous stamens. The fruit is a heart-shaped capsule, first carmine red, then dark brown after drying. It has stiff hairs which stand on end and are dehiscent through two valves. It is grown in warm, humid climates. It produces abundant fruit and its crop requires little care (Figure 3) (Castroviejo:1992:98 and Ferreira:1998:54).

In the same way as other colourants from America, that from the Annatto plant arrived in Europe in the form of pre-prepared cakes and, depending on its place of origin, was mixed with other substances. In this way, treatises on dyeing describe the dyeing method from the pre-extracted colourant.

According to the literature, the method to prepare the annatto colourant varied depending on the region. Thus, to perform the first test, a cold extraction of seeds was chosen, a method cited by the vast majority of the studies done. The method consisted in soaking the same amount of seeds in relation to the dry silk fibres in deionised water for approximately 24 hours. The following day, the seeds were slightly pulverised by hand and then pulverised with a mortar to extract the largest possible amount of colourant. Next, the colourant solution was heated to a maximum temperature of 90ºC for 1 hour. The solution was then strained through fine 32-strand nylon, and was left ready for the preparation of the dye bath. The resulting material was a thick solution of a very distinct brick red colourant.

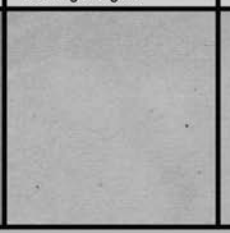
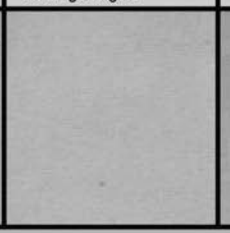
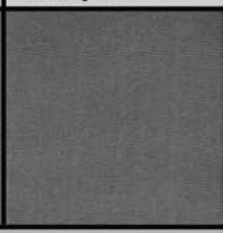
Figure 5. Fruit and seeds from the Annatto

Annatto - *Bixa orellana* L. **Main colouring matter:** Bixina and Nor-bixina **Chemical basis:** Carotenoid **Origin:** plant (annatto seeds) **Classification:** 'minor' of 'false' dye	Colorant extracted from the red seeds powder of the annatto fruit, small tree that is about 3 to 6 m high. Color ranges from golden yellow to orange. Commonly used in Central and South America by indigenous cultures and used in Europe since the 17th century.

Dyeing optimization
18th century: the colorant Europe imports annatto shaped into small cakes. Nowadays only seeds are imported.

Extraction of the dye
. The seeds are immersed into deionized water for 24 h.
. The seeds are crumbled to extract the colorant.
. The solution is heated to 90º for 60 seconds.
. The solution (a vibrant red color) is filtered through a nylon net (32 yarns).

Dyeing method
.the added solution of deionized water is enough to immerse the fabric to be dyed. The fabric has been previously wetted.
.the temperature of the bath is about 70ºC (1 h). The fabric is cooled, rinsed off and let it dry inside.

Test 1 Sample T0000-07	Test 2 Sample T0010-07	Test 3 Sample T0063-08	Test 4 Sample T0064-08	Test 5 Sample T0065-08	Test 6 Sample T0066-08
. direct dyeing	. Mordant: Alum (20%)	Annatto + bleach from olive pits (50%) . Mordant: Alum (20%)	Annatto + Sodium Carbonate (20%) . Mordant: Alum (20%)	Annatto *veil* in bleach from olive pits (T0063-08) +Indigo vat.	Annatto *veil* in Sodium Carbonate (T0064-08) + Indigo vat.
. pH (dyeing bath): 5,5	. pH (dyeing bath): 6-7	. pH (dyeing bath): 6,8	. pH (dyeing bath): 7	. pH (dyeing bath): 6,8	. pH (dyeing bath): 7
. Golden orange	. Orange to gold	. Orange to gold	. Orange to gold intense	. Pistachio green.	. Ollive green
					

MACQUER,1771:107. Light colors tend to change and deteriorate easily. *Colors obtained from annatto however are so beautiful that is worthy using them as, as it is known, beauty is always preferred to durability.*
FERNANDEZ,1995: 20 colors and shades were identified for annatto *dorados, imperiales, granados, mordorés, punzós, acanelados, atabacados, auroras, colores de fuego, colores de sangre y pies para verdes.*

Table 2. Dyeing tests done with Annatto

In the concentrated dye solution, sufficient deionised water was added to completely immerse the fabric to be dyed prior to proceeding to the dyeing process. The previously wetted fabric was immersed, the temperature of the solution was increased to 70ºC, and it was maintained for 1 hour.

The first dye test (T0000-07) with the annatto colourant was carried out together with the direct dyeing process. The result was a yellowish-gold colour, like the shades described in the treatises. However, the orange-red colour, like that of the liquid colourant extracted from annatto seeds, was not obtained. During the dyeing process, the fabric was completely dyed red. After rinsing however, the strong red colour completely left the fabric to leave only the orange-yellow shade fixed on the fibres.

The second test (T0010-07) with the dye was carried out using a previous staining of the silk with alum. From that dye, a golden-yellow shade was obtained, a somewhat less intense shade than with the previous dye.
The third dye test (T0063-08) with the annatto colourant was carried out according to Luis Fernández's recipe which used the dye mixed in the same proportion of ash lye to control the pH of the bath solution. In this case, ash lye from calcinated olive stone was used. The dye consisted in mixing lye into the dye bath and immersing the fabric which was previously stained with alum. The result was a more intense golden-yellow shade.

For comparison purposes, a fourth dye test (T0064-08) was performed using calcium carbonate to control the pH. It involved mixing 20% of the product in deionised water and later adding it to the solution. This dye produced a more vivid orange-gold with a higher concentration of red than the previous dye.

To finish, two additional dyeing processes were carried out with the annatto colourant on the samples from the two previous dyeing processes as a dye base for green shades. The first (T0065-07) consisted of using the dye (T0063-08) with a subsequent indigo bath. This dye produced a slightly bluish-green colour. The second (T0066-07) process used the dye solution (T0064-07), which was followed by an indigo bath to result in a shade close to pistachio green.

Turmeric
Turmeric, or *Curcuma longa L.*, is a herbaceous plant of the *Zingiberáceas* family which reaches a height of between 100-150 cm., and is very well-known for its yellow rhizomes. From the rhizomes, enormous smooth, oblong leaves of a light green colour develop vertically, culminating at the top. Cylindrical, white flower heads with a pink to light green flushing sprout from the floral trunks. The plant rhizome contains a very intense yellow colourant component, which is highly valued and widely used for different purposes (Figures 4 and 5) (Castroviejo: 1992:101 and Ferreira: 1998:45).

Turmeric - *Cúrcuma longa L.* **Main colouring matter:** Curcumin **Chemical basis:** Curcuminoid **Origin:** plant (Curcumin roots) **Classification:** 'minor' of 'false' dye	Plant classified as Zingiberacea that is usually about 100 to 150 cm high. A yellow colorant can be obtained in a strong concentration from its roots. It is a valuable yellow that has been widely used.

Dyeing optimization

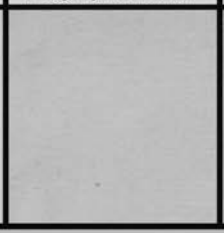
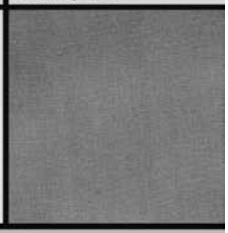
The colorant is supplied as powder and also as little fragments of curcuma roots.

Extraction of the dye

. The fragments of roots are crumbled to obtain the powder (100% according to the dry fiber).
. The powder is put into hot deionized water (60ºC).
. The solution is heated to 90º for 45seconds.
. The solution (a vibrant red color) is filtered through a nylon net (32 yarns).

Dyeing method

. The added solution of deionized water is enough to immerse the fabric to be dyed. The fabric has been previously wetted.
. The temperature of the bath is about 70ºC (1 h). The fabric is cooled, rinsed off and let it dry inside.

Test 1 Sample T0008-07	Test 2 Sample T0028-08	Test 3 Sample T0055-08	Test 4 Sample T0057-08	Test 5 Sample T0059-08	Test 6 Sample T0060-08
. direct dyeing	. Mordant: Tin (10%)	. Mordant: Alum (20%)	. Mordant: Alum (20%) T0055-08 + Sodio Carbonate bath (5%)	Turmeric *veil* 70% colorant according to the dry fiber. . Mordant: Alum (20%)	Turmeric *veil* 70% (T0059-08) + Indigo vat.
. pH (dyeing bath): 7	. pH (dyeing bath): 6	. pH (dyeing bath): 6	. pH (dyeing bath):6 & 8,2	. pH (dyeing bath): 6,8	. pH (dyeing bath):6-8
. Golden yellow	. Golgen yellow intense	. Golden yellow to green	. Red tile	. Light yellow.	Bluish green
					

HELLOT,1752:451: Turmeric is not recommended for a good dyeing of silks, but it was used in combination with major dyes to increase density in yellow and green tones, to obtain golden shades in weld yellows and to blend red colors.
FERNÁNDEZ.,1995:105: *Todos quantos colores tiene este Tratado, se pueden tintar firmes, y permanentes, usando de la Curcuma...pero después de tintados, y arreglados à sus muestras, se les ha de dar un agrio de Limon, ò Vinagre para concluirles...*

Table 3. Dyeing tests done with Turmeric

Cotton standard	L*	a*	b*
C	88,3 ± 0,7	2,867 ± 0,006	-11,897 ± 0,006
C39	87,75 ± 0,06	6,4 ± 0,1	-5,39 ± 0,05
C35	79,1 ± 0,4	16,4 ± 0,9	12,1 ± 0,8
C43	87,814 ± 0,008	6,11 ± 0,02	-5,23 ± 0,03
C51	82,97 ± 0,04	7,981 ± 0,007	3,972 ± 0,013
C52	70,47 ± 0,02	12,50 ± 0,04	-4,381 ± 0,013
C53	60,24 ± 0,03	15,82 ± 0,03	-8,46 ± 0,02
C48	63,7 ± 0,1	16,02 ± 0,08	-7,65 ± 0,05
C26	61,92 ± 0,06	2,96 ± 0,02	5,78 ± 0,02

The colourant from the turmeric plant is available on the market as a powder; it is most commonly used as a seasoning and food colouring, or as small pieces of rhizome which is the form of the colourant used for the dyeing tests carried out in this study.

The preparation of the turmeric colourant consisted in grinding the pieces of rhizome in a mortar until they become a fine powder. For the dye, the same amount of powder in relation to the weight of the dry silk fibre was used. Next, the powder was dissolved in hot water, at approximately 60ºC, and was then heated at 90ºC for 40 minutes. After the solution had cooled, it was filtered using 32-strand nylon. The resulting dye solution was a very concentrated, strong and opaque yellow colour.

Afterwards, sufficient deionised water was added to the dye solution in order to completely immerse the fabric. The first dye test (T 0008-07) with the turmeric colourant was performed using the direct dyeing technique by immersing the previously wet fabric in the bath

solution and increasing the temperature to 70ºC for 45 minutes. Once the procedure had been completed, the resulting dye was a very vivid, bright and deep egg yellow colour.

The second dye test (T0028-08) with turmeric was performed by previously staining the silk with 10% tin chloride, which resulted in a very similar yellow colour to that achieved with direct dyeing, but somewhat more intense. The third dye test (T0055-08) was carried out with a previous staining in 20% alum in relation to the dry silk, and resulted in a very bright, vivid and deep yellow colour.

The fourth dyeing process (T0057-08) involved a previous staining of the silk with 20% alum and a subsequent bath in a 5% sodium carbonate solution which produced a very intense brick red colour.

In the fifth dye test (T0059-08), the turmeric colourant was used as a load, or dye base, to produce a green shade. For this dye, a lower concentration of colourant was used, 70% in relation to the dry fibre, which had been previously stained with alum. This dyeing technique resulted in a luminous, slightly muted colour. In the last dye test (T0060-08), the dye base solution was used (T0059-08) with a subsequent indigo bath. The colour produced was a greenish-blue.

CONCLUSIONS

The optimisation of the dyeing processes has provided the colours and shades reflected in the ancient treatises from the 18th century. The pH values significantly influenced the dyeing of the silk with both natural colourants. Therefore at more basic pHs, annatto tends to produce darker shades, while turmeric tends to produce redder shades

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Versión española

TITULO: ***El Achiote y Rizoma en las fábricas españolas del s.XVIII: identificación y optimización de las técnicas de entintado.***

RESUMEN: *Los colorantes amarillos y anaranjados obtenidos de las semillas del achiote y del rizoma de la cúrcuma fueron comúnmente empleados en la tintorería sedera de España en el siglo XVIII. Su optimización, conocimiento del resultado de sus distintas tinciones, bien como sus características principales son de gran importancia para el conocimiento y entendimiento de los tejidos en seda labrada producidos en España en el período.*

PALABRAS CLAVES: *tintes naturales, achiote, rizoma, tinta textil, fábricas españolas*