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Textile dyeing based on natural dyes

Teñido textil a base de colorantes naturales

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Abstract

This study analyzes works carried out regarding the use of natural dyes in the face of the problem of toxicity due to the abuse of synthetic dyes such as chemical anilines, and also shows the first investigations of textile dyeing in fibers of natural and plant origin. (cotton and wool) with natural extracts obtained from leaves, stems and bark to find alternative solutions due to the intrinsic toxicity of the textile dyeing process towards humans and the environment due to waste that reaches the effluents. The leaves and bark of walnut, avocado pit and red onion bark have the property of producing dyes once their oxidation process is complete where it was observed that the amounts of mordants such as salt, sodium bicarbonate and alum influence the obtaining of the colors: mustard yellow, pink and brown-yellow respectively of walnut leaves and bark, avocado pit and red onion bark. The fixations of these colors satisfactorily meet tests of light fastness, wash fastness and rub fastness in cotton and wool - in high, medium and low shades.

Had, Wool, Mordants, Natural fiber, Extract, Toxicity

Resumen

Este estudio, hace un análisis de trabajos realizados referente a la utilización de colorantes naturales ante la problemática de toxicidad por el abuso de colorantes sintéticos como lo son las anilinas químicas, así mismo muestra las primeras investigaciones de teñido textil en fibras de origen natural y vegetal (algodón y lana) con extractos naturales obtenido de hojas, tallos y corteza para encontrar alternativas de solución por la toxicidad intrínseca del proceso de teñido textil hacia el ser humano y el medio ambiente por desechos que llegan a los efluentes. Las hojas y corteza de nogal, hueso de aguacate y corteza de cebolla morada poseen la propiedad de producir colorantes una vez que está completo su proceso de oxidación donde se observó que las cantidades de mordientes como sal, bicarbonato de sodio y alumbre influyen para la obtención de los colores: amarillo mostaza, rosado y café- amarillo respectivamente de hojas y corteza de nogal, hueso de aguacate y corteza de cebolla morada. Las fijaciones de estos colores satisfactoriamente cumplen pruebas de solidez a la luz, solidez al lavado y solidez al frote en algodón y lana- en tonos alto, medio y bajo.

Teñido, Lana, Mordientes, Fibra natural, Extracto, Toxicidad

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Introduction

Nowadays we live in a world in which ecology and environmental protection are changing many patterns of behaviour, which is why there is a great interest in using natural dyes in the textile industry because they are not harmful to humans and do not pollute the environment. In addition, they have important properties such as their stability to light and heat treatments and they are more economical. The dyeing of fibres and natural dyes is a pre-Hispanic process that we can take up again and continue to learn in order to collaborate and support the wool production sectors.

In 2016, Mexico produced 4,854 tonnes of dirty wool and a sheep generates approximately 1 to 3 kilos of fine wool and 2 to 3 kilos of coarse wool depending on the fleece (A visit to the agri-food atlas 2017. Wool another face of sheep, n.d.). Wool is a natural fibre obtained from sheep and other animals through a process called shearing (Feria de las ciencias UNAM).

The National Institute of Statistics and Geography (INEGI) and the National Chamber of the Textile Industry (CANAINTEX) through the document: Knowing the Textile and Clothing Industry provides figures regarding the Textile and Clothing Industry which contributed 3.2% of the GDP of manufacturing industries and ranked tenth among the most important manufacturing economic activities in 2019. The State of Hidalgo is also among the Entities that recorded the highest production in the textile industry, with 12.6% (as a percentage of the national total). Out of every 100 pesos of inputs used by the textile industry, 58.9 are national and 41.1 are imported; for the garment industry, 57.1 are national and 42.9 are imported. Therefore, the findings of this first stage of research show the results of the textile dyeing process with fibre of natural and vegetable origin (wool and cotton). Experiments were characterised at different concentrations of extract obtained from leaves, stems and bark, obtaining colour fixation in pink, brown and mustard tones.

Colouring in Mexico

Leticia Arroyo Ortíz, a researcher at UNAM, is a plastic artist and teacher at the National School of Plastic Arts of UNAM. She studied painting and textiles at the School of Plastic Arts in Bucharest, Romania. She has studied endemic colours of cultural, economic and historical importance. In Mexico, seven dye materials stand out among a great diversity: cempasúchitl, indigo, palo brasil, palo campeche, zacatlaxcalli, purple snail and grana cochinilla. The latter two are the only known dye animals in Mexico. With 20 years of research work, with works such as the book "Los tintes naturales mexicanos y su aplicación en algodón, henequen y lana" (Mexican natural dyes and their application in cotton, sisal and wool). In Mexico we have a great diversity of dye plants, dominated by yellow, ochre, blue, red, violet and black dyes produced from indigo, cochineal and palo Brasil (Ortíz, 2011).

The grana cochineal (Dactylopiuscoccus) is a parasitic insect of the nopal cactus (La grana cochinilla, 2001).

In some regions of Mexico, the indigenous people still use the indigo dyeing process. This is the case in Hueyapan, in the highlands of Puebla, where the preparation of the dye includes lime, elder leaves, yucca and indigo powder, all mixed in a pot. An indispensable element in indigo dyeing is the muitle, from whose leaves green or blue can be obtained, and it is always added to the indigo vat because it accentuates the colour. Indigo has within its composition some minerals. The temperature is monitored for four days in order to prevent the mixture from precipitating and the indigo from becoming insoluble in water and not adhering to the fibre. The indigo dyeing technique has been preserved from generation to generation, so the ritual is also present; in the pot, in addition to the plants, a lime cross is painted and a rolled-up doll is placed to guarantee the success of the dyeing.

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When dyed with indigo we can observe that, when the fabric is dipped in the dye, it acquires a green colour and when it is put to dry, the indigo comes into contact with oxygen and gives up electrons, i.e., it oxidises, then they are received by the oxygen which is reduced and this oxidation-reduction reaction becomes visible when the colour of the fabric turns blue (Ortíz, 2011).

Indigo's original habitat is not clearly defined. In Guatemala it is known as Guatemalan indigo, in Africa as wild indigo and in the United States as grass indigo (indigoferasuffruticoa). It is a shrub-like plant also known as "Jiquilite", it reaches a height of 1 to 2 metres and produces reddish flowers grouped in clusters and fruit in pods, it belongs to the leguminous family and is the original source of the dye called indigo. Indigo extract is used for dyeing fabrics, especially denim.

The ancient Mayans mixed it with some clays to produce the beautiful "Maya Blue" colour. It is still cultivated locally by a few people in some parts of the country, such as Santiago Niltepec located in the Isthmus of Tehuantepec Oaxaca, where it is grown and the dye is extracted in an artisanal way (Agro Cultura Mexicana, n.d.).

The muicle is native to Mexico and Central America and has been used since pre-Hispanic times in traditional Mexican medicine. It grows in the southeast of the country, Chiapas and Quintana Roo, as well as in the centre of the country, Morelos and in the valley of Mexico. This plant is also used for medicinal purposes (Muicle, a Mexican medicinal plant).

Regarding the Walnut tree (Juglans regia L), the walnut tree in Hidalgo, with good care, can produce up to 50 kg of walnuts and live more than 200 years. In the State of Hidalgo, 3,135 tons of walnuts were obtained, representing 1.97% of the national annual production, occupying the sixth place within the walnut producing states. The Sierra Baja region of the state of Hidalgo produces 80% of this crop, the state has approximately 900 producers for the two types of walnuts (criollo or pecan) (Government of Mexico).

Therefore, the input of walnut leaves and bark could be accessed, without considering the nut shells (pericarp and endocarp), which are currently considered as municipal solid waste and which are increasing. The aim is to make use of the dye called nogalin, which is produced when the pericarp and mesocarp of the walnut are oxidised (Monserrat, 2013).

Methodology

Textile dyeing process using fibres of natural and vegetable origin (cotton and wool, respectively). In order to carry out the dyeing technique, different concentrations of leaves, stems and bark were experimented with, obtaining the following characterisation tests, which are described below.

Optimum quantities found for the textile dyeing process with walnut bark and leaves:

	Walnut bark/leaves (g)	Water (ml)	Animal fibre (lana). (g)	Fibre of vegetable origin (cotton). (g)	Time to obtain the extract (min)	Mordi-ente: Salt (g)	Time extract with mordant (min)	Time Extract-mordant-fibre (min)
1	1000	1000	200	200	30	30	30	30
2	500	1000	200	200	30	30	30	30
3	250	1000	200	200	30	30	30	30

Table 1 Optimum quantities, tests with walnut bark and leaves

Optimum quantities found for the textile dyeing process with avocado pits.

	Stone of avocado (g)	Water (ml)	Animal fibre (lana). (g)	Fibre of vegetable origin (cotton). (g)	Time to obtain the extract (min)	Mordi-ente: Salt (g)	Time extract with mordant (min)	Time Extract-mordant-fibre (min)
1	1000	800	200	200	30	30	30	30
2	500	800	200	200	30	30	30	30
3	250	800	200	200	30	30	30	30

Table 2 Optimum quantities, tests with avocado pits

Optimum quantities found for the textile dyeing process with purple onion peel:

	Red onion peel (g)	Water (ml)	Animal fibre (lana). (g)	Fibre of vegetable origin (cotton). (g)	Time to obtain the extract (min)	Mordi-ente: Salt (g)	Time extract with mordant (min)	Time Extract-mordant-fibre (min)
1	1000	1000	200	200	30	30	30	30
2	500	1000	200	200	30	30	30	30
3	250	1000	200	200	30	30	30	30

Table 3 Optimum quantities, tests with purple onion peel

The following is a description of each of the procedures of the technique experimented with different natural extracts to obtain the textile dyeing samples.

Process of walnut bark and leaves with hanks of natural fibres of animal and vegetable origin:

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1. Weigh 200 g of cotton yarn and 200 g of wool yarn. 2.
2. Cut the walnut bark and leaves into small pieces.
3. In an aluminium container, boil the bark with the water (1000 ml) for 30 minutes to obtain the extract (Note: The time is counted from the beginning of boiling).
4. Extract the liquid (pigment) using a sieve.
5. Add the mordant (30 g of salt) to the extract obtained in the previous step and boil for 30 minutes.
6. Place the previously wet skeins of natural fibre (vegetable or animal) and boil for 30 minutes. Make frequent movements to obtain a uniform dyeing without stains. (Note: The time is counted from the beginning of boiling).
7. Rinse the hanks with cold water until the water runs clear.
8. Allow the skeins to dry hanging in the shade.

The process described above was carried out with characterisation test samples for the quantities and times specified in Table 1.

Processing of avocado pits with hanks of natural fibres of animal and vegetable origin:

1. Weigh 200 g of cotton worsted and 200 g of wool worsted.
2. Cut the avocado pits in half (small pieces).
3. In an aluminium container, boil the pieces of avocado pits for 30 min. in water (1000 ml) to obtain the extract (Note: The time is counted from the beginning of boiling).
4. Extract the liquid (pigment) using a sieve.
5. Add the mordant (30 g. alum) to the extract obtained in the previous point and boil for 30 minutes.
6. Place the previously wet skeins of natural fibre (vegetable or animal) and boil for 30 minutes. Make frequent movements to obtain a uniform dyeing without stains. (Note: The time is counted from the beginning of boiling).
7. Rinse the hanks with cold water until the water runs clear.
8. Allow the skeins to dry hanging in the shade.

The process described above was carried out with characterisation test samples for the quantities and times specified in Table 2.

Process of purple onion peel with hanks of natural fibres of animal and vegetable origin:

1. Weigh 200 g of cotton worsted and 200 g of wool worsted.
2. Remove the onion peel (small pieces).
3. In an aluminium container, boil the pieces of onion peel in water (1000 ml) for 30 minutes to obtain the extract (Note: The time is counted from the beginning of boiling).
4. Extract the liquid (pigment) using a sieve.
5. Add the mordant (30 g of sodium carbonate) to the extract obtained in the previous step and boil for 30 minutes.
6. Place the previously wet skeins of natural fibre (vegetable or animal) and boil for 30 minutes. Make frequent movements to obtain a uniform dyeing without stains. (Note: The time is counted from the beginning of boiling).
7. Rinse the hanks with cold water until the water runs clear.
8. Allow the skeins to dry hanging in the shade.

The process described above was carried out with characterisation test samples for the quantities and times specified in Table 3.

Results

After having carried out the different characterisation tests, tones with the following quantities were obtained:

Shades	Walnut (g)	Salt (g)	Water (ml)	Color	Colour obtained
High	1000	30	1000	Yellow/ mustard	
Medium	500	30	1000	Yellow/ mustard	
Low	250	30	1000	Yellow/ mustard	

Illustration 1. Walnut dyeing

Table 4 Concentrations of walnut

Shades	Avocado pit (g)	Alumbre (g)	Water (ml)	Color	Colour obtained
High	1000	30	1000	Rosé	
Medium	500	30	1000	Rosé	
Low	250	30	1000	Rosé	

Illustration 2. Avocado dyeing

Table 5 Avocado leaf concentration

Shades	Red onion peel (g)	Sodium carbonate (g)	Water (ml)	Color	Colour obtained
High	1000	30	1000	Brown/ yellow	
Medium	500	30	1000	Brown/ yellow	
Low	250	30	1000	Brown/ yellow	

Illustration 3. Onion Dyeing

Table 6 Concentrations of purple onion peel

To guarantee the colour fastness results obtained in mustard yellow, pink and yellow brown, three dyeing efficiency evaluation tests were carried out: light fastness, washing fastness and rubbing fastness, according to standardised parameters. (Textiles, 2020).

Walnut bark and leaves		
Lightfastness		
	Colour change	Colour transparency
White lights	No change	No staining or smearing
		negligible
Yellow lights	No change	No or negligible
		negligible
Washing fastness		
	Colour change	Colour transparency
Our soap	Negligible change	Negligible spotting
Detergent	Slight change	Slight spotting
Rubbing fastness		
	Undergoes deformation	Colour transparency
Dry	Significant change	Light transfer
Wet	Slight change	Light transfer

Table 7 Colour fixation test on walnut bark and leaves

Red onion peel		
Lightfastness		
	Colour change	Colour transparency
White lights	No change	No staining or smearing
		negligible
Yellow lights	No change	No or negligible
		negligible
Washing fastness		
	Colour change	Heat transparency
Our soap	Negligible change	Negligible spotting
Detergent	Slight change	Light spotting
Rubbing fastness		
	Undergoes deformation	Colour transparency
Dry	Significant change	Light transfer
Wet	Slight change	Light transfer

Table 4 Colour fixation test on purple onion rind

Avocado pit		
Lightfastness		
	Colour change	Colour transparency
White lights	No change	No staining or smearing
		negligible
Yellow lights	No change	No or negligible
		negligible
	Washing fastness	
	Colour change	Heat transparency
Our soap	Negligible change	Negligible spotting
Detergent	Slight change	Light spotting
Rubbing fastness		
	Undergoes deformation	Colour transparency
Dry	Significant change	Light transfer
Wet	Slight change	Light transfer

Table 5 Avocado pit colour fixation test

Conclusions

When textile dyeing tests were carried out with walnut bark and leaves, avocado pits and onion bark, solid colours were obtained with good colour fixation in three shades: high, medium and low, combining different mordants in animal and vegetable fibres (cotton and wool). It will be necessary to strengthen strategies for the collection of leaves, stems and bark for the raw material of the textile dyeing process. The state of Hidalgo contributes almost 2% of the national annual production of walnuts, which means that a very economical raw material is available, as its shell is considered a solid municipal waste, as well as avocado pits and onion bark. The by-product (natural dyes) resulting from the waste leaves, stems and bark are sustainable products with applications in the textile industry. Therefore, the technique should be further improved in order to achieve new and better results.

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