

Fabrics dying with *Hibiscus sabdariffa* and *Curcuma longa* extracts using different mordants and mordanting methods

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Abstract

Extraction of plant secondary metabolites were prepared and subjected as non-toxic, biodegradable and eco-friendly natural dyes. Two groups of cotton textiles were dyed with crude extracts of *Curcuma longa* and *Hibiscus sabdariffa* separately to examine and compare the staining ability of these extracts. Fabrics were treated with three different mordanting techniques using three different mordants which were copper, ferrous sulfates and potassium dichromate. Dyed fabrics were exposed to different conditions including washing with water and detergent as well as exposing to sun light in order to test the stability of the color. As a result *Curcuma longa* extract had higher potentially dying ability than *Hibiscus sabdariffa* extract, otherwise using of Potassium dichromate as a mordant gave best color stability compared with other used mordants, while dying of fabrics by pre-mordanting method as exposing fabric samples to the mordants before dying with plant extracts showed the darker shade.

Introduction

Plants have become a major part in mankind life and playing a vital role in many directions, including food, pharmaceutical and industrial aspects. Dyes derived from natural resources such as plant parts have become important and useful resources for dying production throughout thousands of years.

After production of first synthetic dye in 1856, a revolutionary development of production a number of synthetic dyes as alternatives to natural dyes [1]. Although using synthetic dyes has advantages represented by possibility of exceptional low cost and wide range of colors obtained from one resource. There are an environmental issues including pollution, toxicity, carcinogenicity and health risks which are accomplished with these synthetic dyes making the research coming back again to dyes from natural resources with high consideration to the plants as first of these resources [2].

Hibiscus sabdariffa and *Curcuma longa* plants were used as one of plant sources for natural dyes production, suitability aspects of using these plants could be referred to premium pricing.

Roselle, (*H. sabdariffa*) locally known as “Karkade” an aromatic annual herb cultivated in tropical and sub-tropical regions. [3]. The aqueous extract of *H.*

sabdariffa red calyx is commonly consuming as beverage drinks to add red color to the tea that is much used in tropics due to cooling properties of this crop [4]. Among other uses, rosella had a number of biological and pharmaceutical effects such as anticancer, cough, antiseptic and lowering fever. [5]. Otherwise, turmeric, (rhizomes of *C. longa* L.) belongs to the Zingiberaceae family is used in many household purposes including cooking, pickles, soups, flavoring and food preservatives. Furthermore, *C. longa* is well recognized for its anti-inflammatory, anti-oxidant, cancer prevention, lowering cholesterol and also bright yellow color documented using for coloring food [6].

The main aim of this study is to investigate the dyeing ability and the coloring range of *H. sabdariffa* and *C. longa* extracts on 100% cotton fabrics which mordanted by three different materials using three different mordanting methods.

Materials and methods

Materials

C. longa rhizomes and *H. sabdariffa* flowers were purchased from local markets in Baghdad, Iraq. As a substrate 100% cotton fabric was used, locally available in the markets. Solvents, reagents, and

mordants as copper sulfate, ferrous sulfate, and potassium dichromate were used which were manufactured by Fisher company/ Germany.

Methods

Preparation of plant materials

Rhizomes and flowers of *C. longa* and *H. sabdariffa* respectively, were washed well with tap water and dried in shade. The dried materials were ultimately grounded to form a fine powder.

Extraction of Dye

To extract the dye from each plant, different solvents were used. *C. longa* 95 % extracted with ethanol, while water was used as solvent of extract with *H. sabdariffa*.

Twenty grams of dried *Curcuma* rhizomes was weighed and 100 ml of ethanol was added. It was heated to 45°C in a round bottom flask attached to the soxhlet. The extract was then filtered, and the filtrate was used later for dyeing. On the other hand, 10 gm of *Hibiscus* flowers were dipped in 200 ml of hot distilled water overnight. The extract was then filtered for further use.

Mordanting and dyeing

Before starting the dyeing or mordanting procedure, the cotton fabric was processed with solution containing 5g/l of non-ionic detergent for 30 min. In order to remove all the impurities and starch present and for fixing the dye, the fabric was washed carefully with tap water, rinsed and dried at room temperature[7] .

The material then was cut in size 5 x 10 cm for further use. The cotton fabrics were mordanted by copper sulfate, ferrous sulfate, and potassium dichromate. Three different processes of mordanting have been used which were pre-, simultaneous and post-mordanting methods in concentration of 1%.

In the pre-mordanting method, the fabrics were initially mordanted with the three different mordants for around one hour, rinsed meticulously with water, squeezed and dried at room temperature.

To start Dyeing procedure, 10 ml of a dye was added to the mordanted fabrics and kept in a dye bath at 65°

C for three hours. Afterward the dyed samples were dipped in 1% NaCl solution at room temperature for 1 hour for fixing of the dye. The dyed material was dried and subsequently washed in cold water to get rid of extra dye.

The semi-mordanting method was carried out by adding the mordant and the dye together to the fabrics. The materials then were kept in a dye bath at 65° C for three hours. The following steps were exactly as mentioned in the previous method [2].

The third mordanting method (post-mordanting) was begun with dyeing the materials by adding the dye to the fabrics in a dye bath at 65° C for three hours. After removing the dye, the mordants were added. Afterward NaCl solution and the following steps were performed as mentioned above.

Testing the color-fastness

The dyed samples were washed in washing machine using detergent at concentration of 5 gm/l for about 20 minutes. Sun-light fastness was evaluated according to [7]. The dyed samples were exposed to day light behind glass. The half of each dyed fabric was covered with a thick black paper sheet, thus they are not exposed to the light. This testing was carried out in a 24 hour cycle.

Results and discussion

Two groups of cotton fabric consist of three pieces for each different group were dyed with *C. longa* and *H. sabdariffa* extracts separately; dyeing process perfumed by three different mordants and mordanting conditions as pre-, simultaneously and post-mordanting.

Mordanting techniques and mordants types

First of all we should give a light spot to the step of subjected textile to the mordants and its importance in our experiment; mordanting was perfumed due to low affinity between plant origin fabric pieces (cotton) to the dye molecule compared with animal origin fabrics such as wool because of absence of amino and carboxyl groups that lead to using mordants for increasing the affinity .

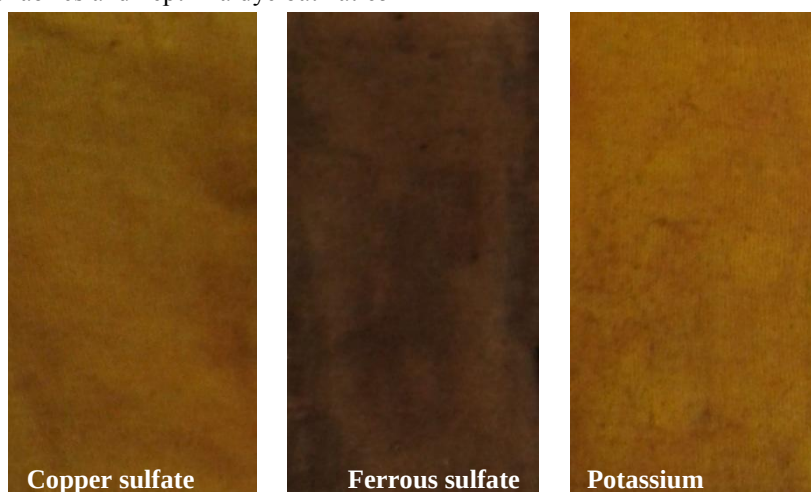


Figure 1. Pre-mordanting method using *Curcuma longa* extract. The fabrics treated with different mordants and washed only with cold water after dyeing

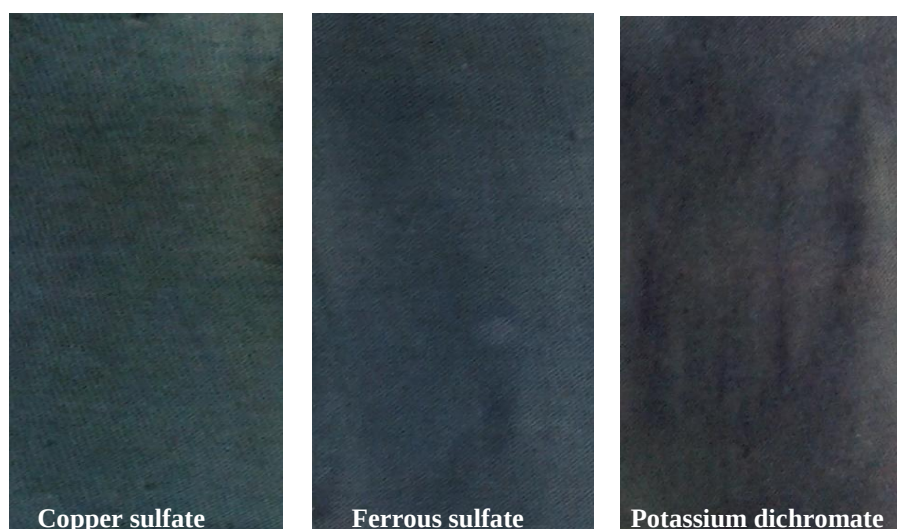


Figure 2. Pre-mordanting method using *Hibiscus sabdariffa* extract. The fabrics treated with different mordants and washed only with cold water after dyeing

In pre-mordanting where the mordants applied prior to dyeing, fabrics showed that the color produced is darker due to a complex formed between metal salt of mordant with fabrics for both *Curcuma* and *Hibiscus* extracts [8]

Generally, the results of pre-mordanting treatment as shown in Figures 1 and 2 gave the darkest shade and these results are in agreement with [9] and [2].

In the case of simultaneously mordanting, the period of dyeing is shorter due to a reduction in the number of steps. This treatment produces generally lighter shades for fabrics; color yield may also be reduced by losing dye-mordant complex formation because some dye and mordant lost in the dye bath which may also cause uneven dyeing [8]. figures (3) and (4).



Figure 3. Semi-mordanting method using *Curcuma longa* extract. The fabrics treated with different mordants together with dyeing and washed only with cold water.

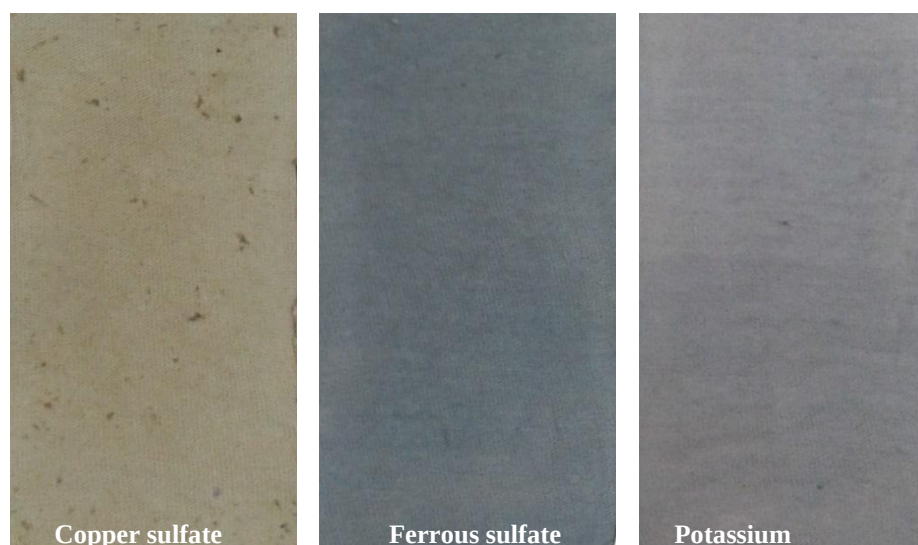


Figure 4. Semi-mordanting method using *Hibiscus sabdariffa* extract. The fabrics treated with different mordants together with dyeing and washed only with cold water.

In the last case of treatment which was post-mordanting that dye added before mordants, fabric samples showed nearly dark color but when

compared with pre-mordanted samples, it was lighter in general. figures (5) and (6).

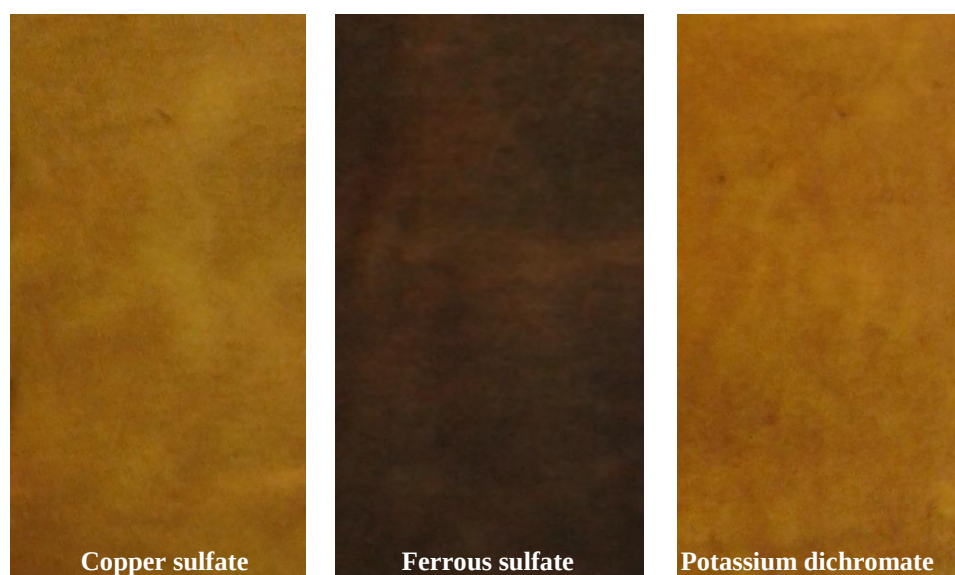


Figure 5. Post-mordanting method using *Curcuma longa* extract. The fabrics dyed then treated with different mordants and washed only with cold water

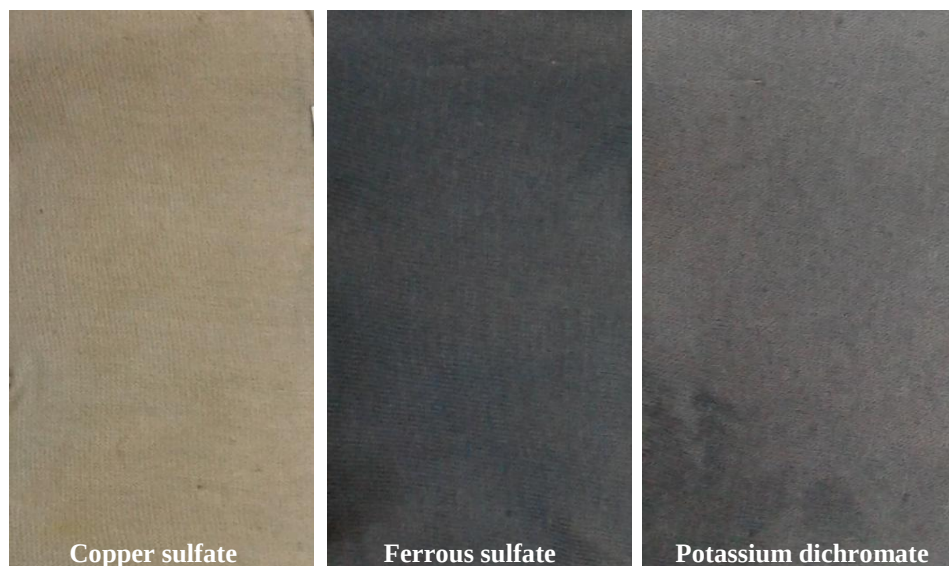


Figure 6. Post-mordanting method using *Hibiscus sabdariffa* extract. The fabrics dyed then treated with different mordants and washed only with cold water

Otherwise, differences in colors of fabrics for the same kind of extract caused by using different metal mordants which were, as shown in figures above, copper sulfate, ferrous sulfate, and potassium dichromate.

In case of using iron salts in form of ferrous sulfate as a mordant seems to impart dark brown or brown to fabrics dyed with *Curcuma* and blue or dark blue of fabrics dyed with *Hibiscus*, while cotton fabrics generally acquired light color when using copper sulfate compared with ferrous sulfate. But when using potassium dichromate as mordant, it gave a yellowish brown with *Curcuma* extract, while provided a blue and greyish blue with the other extract.

Natural dyes of plant origin

Turmeric

Turmeric is a well-known yellow dye which was imparted by curcumin, Using of different mordants and mordanting techniques gave remarkable color strength differences. Results showed that pre-mordanting gives maximum dark color with all mordants except for ferrous sulfate which was the darkest color in post-mordanting treatment compared with others.

Hibiscus

Anthocyanins which is responsible for the red or scarlet color considered as one of the most important color compounds group extracted from *Hibiscus* petals [10].

Using Anthocyanin compounds for dyeing, give a wide range of color spectrum in addition to red including pink, scarlet, blue and violet due to sensitivity of these compounds to pH differences which were obtained by various ways such as type of mordant and nature of detergent used in water fastness [11] results showed that the darkest blue color was fluctuating between potassium dichromate in pre-mordanting method and ferrous sulfate in the post mordanting as shown in the previous figures.

Sunlight fastness is very important in evaluating color strength and stability, [12] reported that fastness as a general is depending on type of mordant and mordanting technique. As the results show, mordanting by ferrous sulfate didn't completely affected by exposure to sunlight compared with copper sulfate and potassium dichromate which the color became lighter for both of the extracts.

However, in fabrics dyed with *Hibiscus* extract, pre-mordanting method showed lighter color compared with other techniques. This might be due to various metal-dye complexes that could be formed leading to differences in their stability to the light.

The fastness of color using *Curcuma* extract was better in pre-mordanting than the other techniques. Ferrous and copper sulfates recorded the best fastness, while the color seems to be less stability using potassium dichromate as shown in figures 7, 8 and 9.

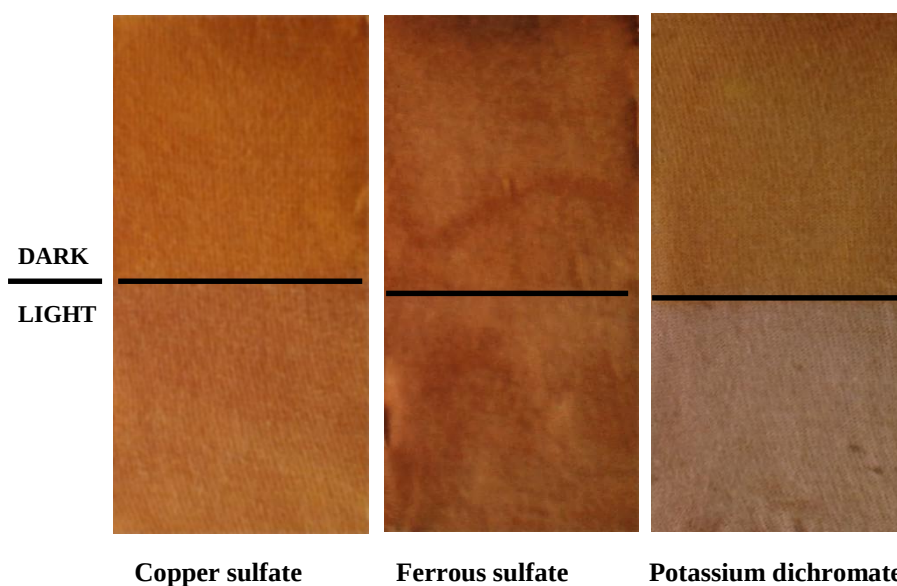


Fig 7: The pre- mordanted fabrics dyed using *Curcuma longa* extract. Washed with 5g/l detergent for 20 min and dried in sunlight. The upper part of each specimen dried in shadow while the lower part exposed to sun light

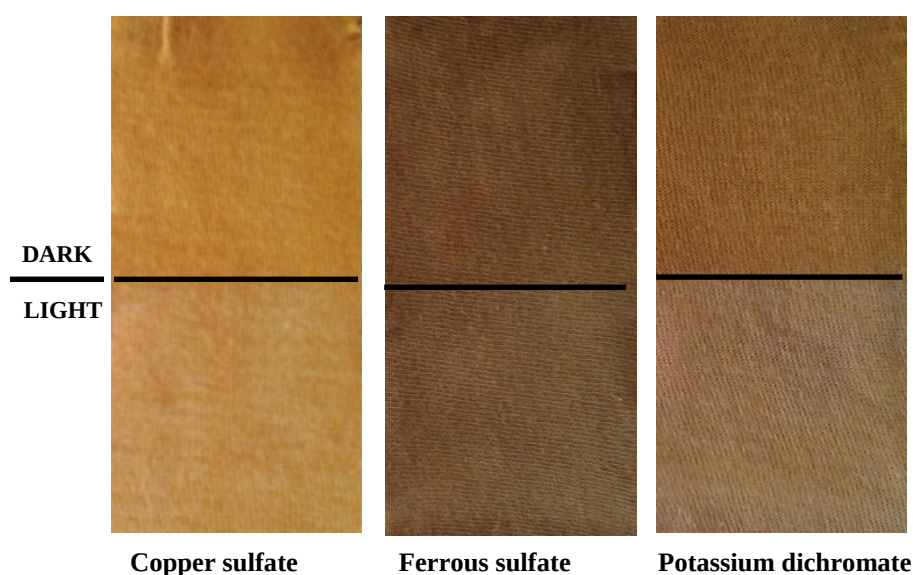


Fig 8: The semi- mordanted fabrics dyed using *Curcuma longa* extract. Washed with 5g/l detergent for 20 min and dried in sunlight. The upper part of each specimen dried in shadow while the lower part exposed to sun light

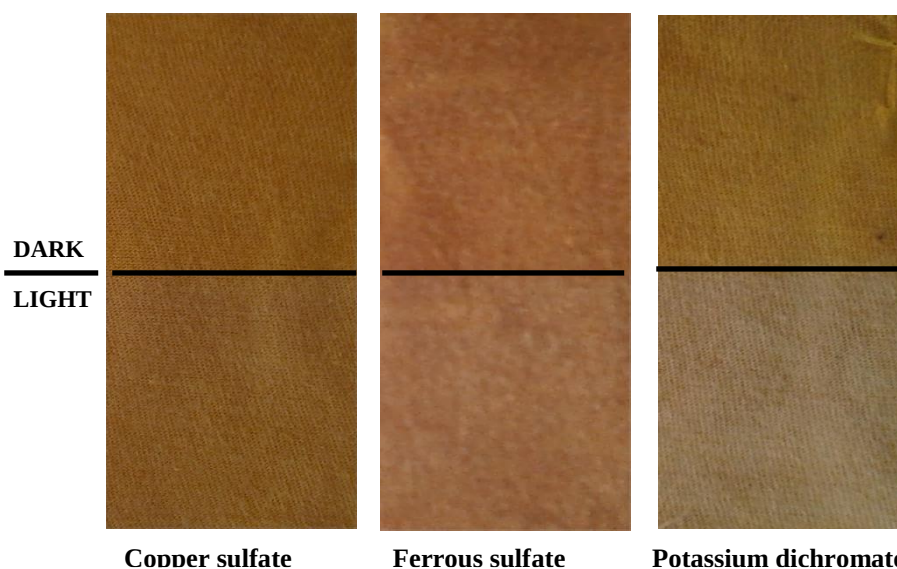


Fig 9: The post- mordanted fabrics dyed using *Curcuma longa* extract. Washed with 5g/l detergent for 20 min and dried in sunlight. The upper part of each specimen dried in shadow while the lower part exposed to sun light.

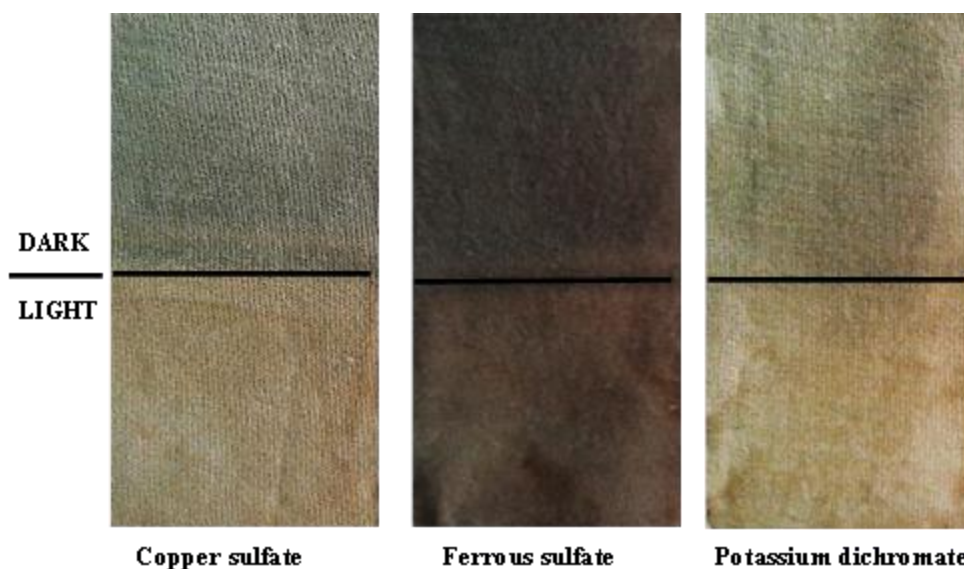


Fig 10: The pre- mordanted fabrics dyed using *Hibiscus sabdariffa* extract. Washed with 5g/l detergent for 20 min and dried in sunlight. The upper part of each specimen dried in shadow while the lower part exposed to sun light

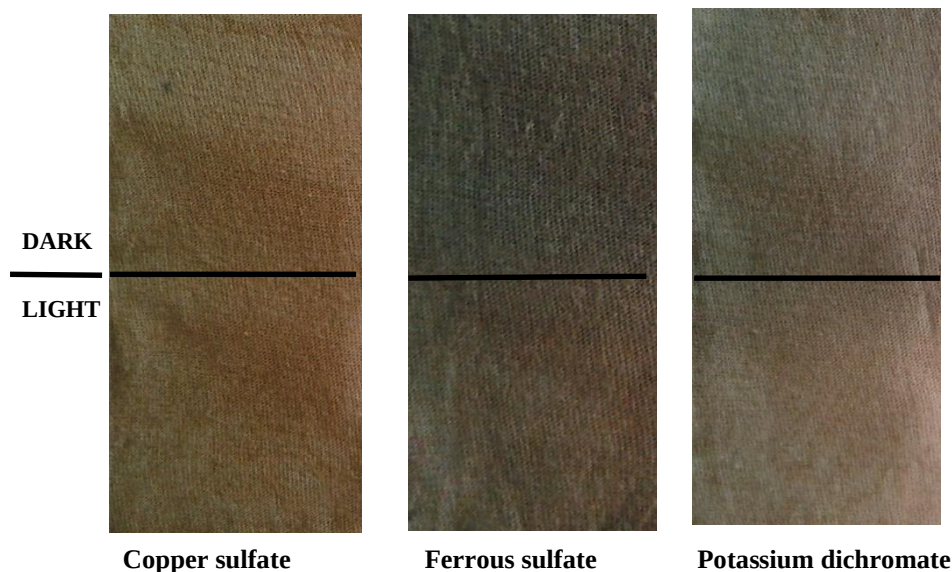


Fig 11: The semi- mordanted fabrics dyed using *Hibiscus sabdariffa* extract. Washed with 5g/l detergent for 20 min and dried in sunlight. The upper part of each specimen dried in shadow while the lower part exposed to sun light

On the other hand, fabrics colored with *Hibiscus* extract, simultaneously mordanting gave the best stability of the color followed by post- and pre-mordanting methods. Figures 10,11 and 12 show that almost all mordants offered a worthy fastness. However, potassium dichromate presented slight differences in stability of the color.

Dying process affected seriously by wash fastness due to presence of ions' detergents caused ionic interaction and non-polar van der Waals' interaction between dye ingredients and textile [12].

Beside previous points, Alkalinity also affected the color shades so rinsing with sodium salts (NaCl) was carried out to obtain a good shade [9].

The range of colors on the same textile substrate produced by the same dye-yielding plant species using different mordants and mordanting technique was remarkable and this is one of the advantages of natural dyeing, therefore nature of natural dye, type of mordant and using different conditions related pH can support dying process with a various color options.

The level of absorption of dye and stability were affected by the unique structures of each natural dye components and on the strength of the mordant coordination complex formed during the dyeing process [13].

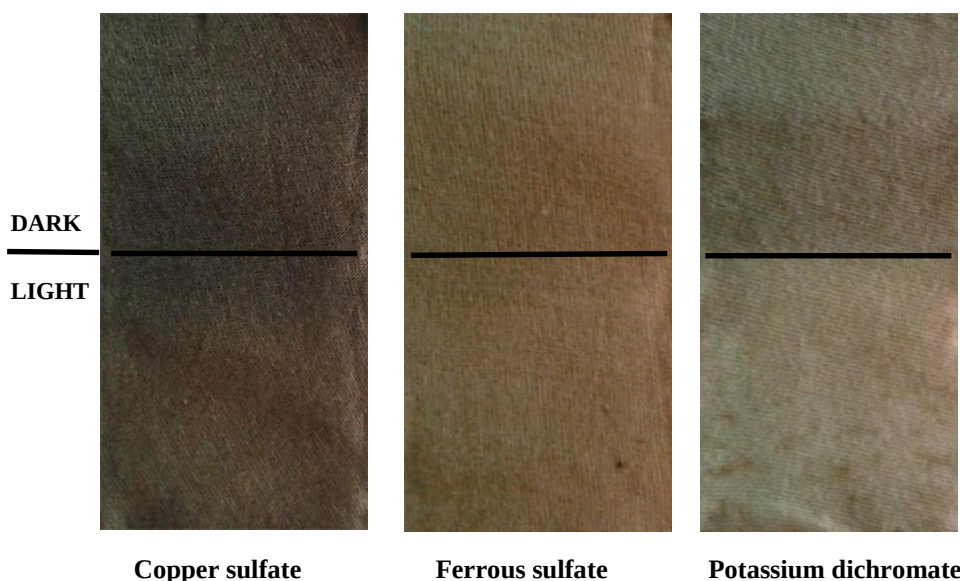


Fig 12: The post- mordanted fabrics dyed using *Hibiscus sabdariffa* extract. Washed with 5g/l detergent for 20 min and dried in sunlight. The upper part of each specimen dried in shadow while the lower part exposed to sun light

Conclusion

The current study generally reveals a strong color shade in *curcuma* extract's dyed textiles in comparison to the textiles stained with *Hibiscus* extracts.

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Though, the fastness of the color fluctuated between both extracts depending on the type of the mordant and the method of mordanting that was used.

Remarkably, potassium dichromate treated textiles gave relatively good stability of the color in *Hibiscus* dyed samples in comparison with *Curcuma*'s.

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تصبيغ الانسجة بمستخلصي الكجرات والكرم باستخدام مثبتات وطرق تثبيت مختلفة

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الملخص

استخلصت مركبات نباتية طبيعية وهيأت كأصباغ غير سامة وقابلة للتحلل الحيوي وصديقة للبيئة. صبغت مجموعتين من الأقمشة القطنية بصبغات مستخلصة من الكرم والكجرات كل على حدة لمقارنه واختبار قابلية المستخلصين للتصبيغ، عوملت الاقمشه بثلاث انواع من المثبتات وهي: النحاس وكبريتات الحديدوز وكرومات البوتاسيوم الثنائية قبل التصبيغ وبعده واثاء التصبيغ. عرضت الأقمشة المصبوغة الى الغسل بالماء والمنظفات وضوء الشمس لأختبار ثباتية اللون، اظهرت النتائج ان مستخلص الكرم له قابلية تصبيغ افضل من مستخلص الكجرات ومن ناحية اخرى اعطى مثبت كرومات البوتاسيوم الثنائية استقرارا" للون افضل مقارنه بالمثبتات الاخرى المستخدمة بالتجربة، بينما تبين ان معاملة الأقمشة بالمثبتات قبل التصبيغ اظهر لونا" غامقا" مظلا".