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Testing the Fastness to Light and Washing of Fabrics Dyed with *Allium cepa* and Turmeric Extracts

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ABSTRACT
With the growing emphasis on sustainable textiles, the preference is gradually shifting to natural dyes that are biodegradable and less toxic. Despite the growing preference for natural dyes across the world, the use of natural dyes is still not so profound in Nigeria. Only peoples like the Yoruba of southwest and the Hausa of the north of Nigeria, use indigo dyes to produce the famous *adire* (tie-dyed and batik) fabrics, while artisans in various parts of the country use Allium Cepa (onion peel), and some fabric producers in Ekiti State use turmeric as dye. Using six separate experiments in studio methods and exploring Alum ($XAl(SO_4)_2 \cdot 12H_2O$) as mordant, this study sought to find out the fastness to light and washing of sample fabrics dyed with Allium cepa and turmeric dyes. In all the six experiments, 200g of the active dye agent was used, in conjunction with 50g of the mordant. Results indicated that naturally dyed fabrics should not be washed with detergent but mild soaps to avoid any form of colour degradation.

KEYWORDS: Textiles, Allium Cepa, turmeric, Dyeing, fastness to light and washing

Introduction

Natural dyes flourished until the discovery of synthetic dye in 1856 by an English teenage chemist, William Henry Perkin. The advent of the synthetic dyes brought about a drastic drop in the use of natural dyes, because of their overwhelming advantages. Unlike natural dyes, they could be produced promptly and in vast quantities, industrially. In addition, they exhibited a higher degree of colour fastness, which is the tendency of a dye or pigment to maintain its original hue without running or fading when washed or exposed to light, heat or other agents of degradation. Unlike the synthetic dyes, natural dyes do not have appreciable fastness to light and washing. Highlighting this fact, Virendra (2019) posited that the major challenges natural dyed textiles have are good colour fastness to washing and light, non-availability of well-defined standard procedure for application, and reproducibility of shade.

While various peoples and experts have developed their own methods and processes for using natural dyes, there is a need for further researches on natural dyes to provide more definite information about application and colour fastness generally. As the world moves towards sustainability of resource use, there has been a corresponding dwindling in the use of synthetic dyes. Aparna (2013) siting the World Commission on Environment and Development (WCED), explains that sustainability is "to meet the needs of the present without compromising the ability of future generation to meet their needs and desires". What this rightly means is that, in our quest to take care of the present, we should be cautious not to endanger the future generations. The processes of making synthetic dyes (and the dyes themselves) are known to be very hazardous to the environment and also harmful to the users who might inhale the fumes. Indelible facts have been militating against the continued use of synthetic dyes lately. With the growing emphasis on sustainable textiles, the preference is gradually shifting to natural dyes that are biodegradable and less toxic. In addition to the drift towards natural dyes, there has been a conscious effort to sourcing fibres that are environmentally friendly too. While sustainability in fibre sourcing and dyes production are becoming paramount, it is pertinent to note

that the degree of dyes' fastness is a major measure of durability. Colour fastness is the factor of how colours can remain unchanged when several factors impinge them. Thus colour fastness is always measured or tested to factors such as washing, light, perspiration, water, rubbing, sea water, pressing, chlorinated water, and laundering (Kiron 2021). Whenever fabrics are worn outdoors, they are subjected to sunlight of varying intensity, which can impact negatively on the colour, if the dye is not light fast. In textile technology, colour fastness test is geared towards determining the measure of resistance a dyed fabric has to the degrading power of impinging factors for a period of time. To test colour fastness to light, for instance, the level of degradation can be graduated as outlined Table 1.

Table 1 shows the possible levels of degradation or fastness for a dyed fabric exposed to sunlight for a specified period of time. There is a gradual depreciation from grade 8 with no fading to grade 1 with very extensive fading. While grade 8 represents outstanding fastness to light, grade 1 has very poor fastness to light. Kumar (2014) defines light fastness as the resistance of dyes and pigments to the effect of sun heat and light energy. He affirms that the ultraviolet rays, which contribute about ten percent of the total light output of the sun, accelerate the fading of dyes. Thus, the more the exposure to these ultraviolet rays, the more the possibility of a dyed fabric gradually or rapidly losing its shade(s) of colour.

In another sense, the degree of degradation of a dyed fabric by sunlight is often dependent on certain factors beyond light itself. Some of these factors are outlined below.

Amount of unfixed dyes

When a larger proportion of the dye molecules are unfixed on the fabric, there is a high tendency of poor fastness to light. Properly fixed molecules exhibit great fastness to light.

Depth of Shade

Darker shades of dye have good resistance to light, while lighter shades exhibit poor resistance. This is attributable to the fact that only few molecules of the larger number of dye molecules in the dark shades are affected. More molecules are affected by light in the lighter shades that have fewer molecules.

After treatment

Some after treatments like size shield the dyed fabric from degradation by light. Hence, sized fabric could show better fastness to light than unsized ones.

Environmental conditions

High moisture and heat make the fabric to have poor resistance to light.

Fibre characteristics

The structural make-up of the fibre could determine how much the dye molecules bind to the fibre. Where there is a strong bond, there is equivalent good fastness to light.

The Use of Natural Dyes in Nigeria

Despite the growing preference for natural dyes across the world, the use of natural dyes is still not so profound in Nigeria. Only some indigenous fabric decorators in Western and Northern Nigeria majorly use natural dyes like indigo dye that gives various shades of blue. The Yoruba use indigo dyes to produce the famous *adire* (tie-dyed and batik) fabrics. For the contemporary textile designer, the blue of indigo dye does not cater to diversity of colour. However, other organic materials like *Allium cepa* (onion peel) and turmeric (Figs. 2 and 3) are good fabric colourants that do not need mordants to be potent. In addition, they are cost effective, readily available around Nigeria and the extraction processes are not as laborious as that of the indigo dye. While the use of *Allium cepa* is not peculiar to any location in the country, turmeric has a wider use

Table 1: Light Fastness Grades

Grade	Degree of Fading	Light Fastness Type
8	No fading	Outstanding
7	Very slight fading	Excellent
6	Slight fading	Very good
5	Moderate fading	Good
4	Appreciable fading	Moderate
3	Significant fading	Fair
2	Extensive fading	Poor
1	Very extensive fading	Very poor

Source: Kiron (2021)

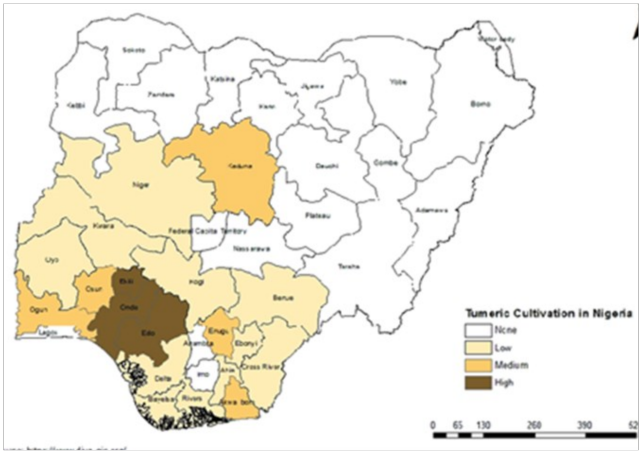

Fig 1: Turmeric Cultivation in Nigeria. Source: https// www.diva-gis.org.

Fig 2: Allium Cepa (papery covering of Onion)
Photo: Paul Aikhionbare, 2016

Fig 3: Turmeric (Curcuma Longa).
Photo: Paul Aikhionbare,2016

within a bulk of the nation's geography (Fig. 1).

According to a survey done by Akinpelu (2012) more people in Ekiti State use turmeric as herbal medicine than as fabric dye. While the blue shades of indigo dyes are good, a variety of other colours can be achieved using other organic and sustainable sources, to maintain variety in design. Variety in colour not only provides choices, but is the component of design that helps to avoid monotony. This paper reports a studio experiment into the colour fastness of *Allium cepa* and turmeric when used as fabric dyes. Using six separate experiments in studio methods and exploring Alum ($XAl(SO_4)_2{\cdot}12H_2O$) as mordant, this study sought to find out the fastness to light and washing of sample fabrics dyed with *Allium cepa* and turmeric extracts. In all the six experiments, 200g of the active dye agent was used, in conjunction with 50g of the mordant. A yard of cotton fabric, cut in two, was also used in all cases, so that one half was the control for each experiment. The process and results are presented in Experiments 1-6.

Experiment 1: Colour Fastness to Light Test for a Fabric Dyed with *Allium cepa*

Technical Details
Fabric Type: Cotton
Yardage: 1
Herb: *Allium cepa*
Weight: 200g
Mordant: Alum - $XAl(SO_4)_2{\cdot}12H_2O$
Weight: 50g

Procedure
200g of *Allium cepa* and 50g of mordant (Alum) were boiled for about 30 minutes. The aqueous solution of *Allium cepa* and Alum was sieved and the fabric was immersed for 45 minutes. The resultant dyed fabric was cut into two equal halves. While one half served as control specimen, the other was exposed to sunlight for ten hours. Thereafter, the two swatches were placed side by side and visually examined to ascertain the degree of fastness to light.

Fig 4: Control fabric dyed with the aqueous solution of *Allium cepa* and Alum. Photo: Paul Aikhionbare, 2019

Fig 5: Specimen *Allium cepa*-dyed fabric exposed to 10hours of sunlight. Photo: Paul Aikhionbare, 2019

Taking a comparative look at Figs. 4 and 5, it can be observed that very slight fading occurred in Fig. 5 as a result of degradation by sunlight for those hours of exposure. Going by Kiron's light fastness grade table, the dyed fabric can be said to have very good fastness to light, which is grade 7. This implies that *Allium cepa* has excellent fastness to light when applied on cotton.

Experiment 2: Colour Fastness to Light Test for a Fabric Dyed in an Aqueous Solution of Turmeric

Technical Details
Fabric Type: Cotton
Yardage: 1
Herb: Turmeric
Weight: 200g
Mordant: Alum - $XAl(SO_4)_2 \cdot 12H_2O$
Weight: 50g

Procedure
The 200g of turmeric and mordant (Alum) were boiled for 30 minutes. The aqueous solution of turmeric and Alum was sieved and the fabric was immersed in it for 45 minutes. The resultant dyed fabric was cut into two equal halves. One half served as control specimen, while the other was exposed to daylight for ten hours. Thereafter, the two swatches were placed side by side and visually examined to ascertain the degree of degradation by sunlight.

A comparative study of Fig. 6 (control fabric) and Fig. 7 (experimental fabric) indicates a slight fading of the experimental fabric. This places the fabric on grade 6 of Kiron's light fastness grade table - ascribing turmeric dye good fastness to light, when applied on cotton fabric.

Colour Fastness to Washing Test
Textile fabrics have varying tendencies to hold dye molecules within their fibres when subjected to washing action. While some fabrics have great ability to hold the dye molecules within, others like the synthetic fabrics have low ability to hold the dye molecules within the fibres when washed. Colour fastness to washing is the resistance of a fabric to colour change when subjected to washing action. A quick way to do colour fastness to washing test is to dampen a clean white piece of fabric and rub against a coloured fabric. If the white fabric gets stained with the colour of the coloured fabric, it means the dye will run when the fabric is washed. Some factors could determine the extent to which a coloured fabric will run:

- The degree of agitation during washing is one of such factors. The more the agitation, the more the tendency for the colour to run. Thus, it is advisable to apply lesser washing force on a fabric that has the tendency to run.
- The type and quantity of detergent used could also determine the extent of colour loss during washing. Some detergents are harsh on coloured fabrics and it becomes worse when the washing bath has concentrated amounts of it.
- The temperature at which the fabric is washed is also a factor to be considered. The temperature should be conducive enough not to discharge colour from the fabric.
- The ratio of the washing liquid to the fabric could determine how much colour runs during washing.

Fig 6: The control fabric dyed in an aqueous solution of turmeric. Photo: Paul Aikhionbare 2019

Fig 7: Resultant dyed fabric in the aqueous solution of turmeric subjected to 10 hours of daylight.
Photo: Paul Aikhionbare 2019

The ratio should be such that the fabric is not subjected to a highly concentrated environment during washing.

Experiment 3: Colour Fastness to Washing Test for a Fabric Dyed in an Aqueous Solution of Allium Cepa, Using Detergent

Technical Details
Fabric Type: Cotton
Yardage: 1/2
Herb: *Allium cepa*
Weight: 200g
Mordant: Alum - $XAl(SO_4)_2{\cdot}12H_2O$
Weight: 50g
Soap: Detergent

Procedure
The fabric to be tested was soaked for 45 minutes to pre-dye with *Allium cepa* and alum, and then cut into 2 equal halves. One was kept aside as control fabric while the other was the experimental fabric subjected to severe hand wash using detergent for ten minutes (Fig. 8). The washed piece of fabric was thoroughly rinsed with water and placed side by side with the control fabric and visually examined to ascertain the level of fastness to washing.

Comparing the washed experimental fabric (Fig. 10) and the control fabric (Fig. 9), it is visually obvious that there has been some degree of degradation caused by the detergent. There are two possible factors for the extent of degradation: (i) the type of detergent (ii) the quantity used. Despite these factors, it could be safe to say it is not appropriate to use detergent to wash fabrics dyed with *Allium cepa*.

Experiment 4: Colour Fastness to Washing Test for a Fabric Dyed in an Aqueous Solution of *Allium cepa*, Using Laundry Bar Soap

Technical Details
Fabric Type: Cotton
Yardage: 1/2
Herb: *Allium cepa*
Weight: 200g
Mordant: Alum - $XAl(SO_4)_2{\cdot}12H_2O$
Weight: 50g
Soap: Laundry Bar Soap

Procedure
The fabric to be tested was soaked for 45 minutes in the *Allium cepa* and alum solution to pre-dye and was then cut into two equal halves. One half of the fabric served as the control specimen while the other was the experimental one subjected to severe hand wash using laundry bar soap for ten minutes (Fig. 11). The washed piece of fabric was then rinsed with water and placed side by side with the control specimen for comparative visual observation and analysis.

Looking comparatively at the control specimen (Fig. 12) and the washed experimental fabric (Fig. 13), one could observe a slight degradation of the dyed fabric after being washed with the laundry bar soap. This implies that fabrics dyed with *Allium cepa* are not susceptible to much degradation when washed with mild soaps like laundry bar soap.

Fig 8: Washing fabric dyed in aqueous solution of *Allium cepa* with detergent. Photo: Paul Aikhionbare 2019

Fig 9: Control fabric dyed in an aqueous solution of *Allium cepa*. Photo: Paul Aikhionbare 2019

Fig 10: Resultant state of a fabric dyed in an aqueous solution of *Allium cepa* after washing with detergent. Photo: Paul Aikhionbare 2019

Fig 11: Washing the fabric dyed in an aqueous solution of *Allium cepa* with laundry bar soap. Photo: Tova Aikhionbare, 2019

Fig 12: Control fabric dyed in an aqueous solution of *Allium cepa*. Photo: Paul Aikhionbare, 2019

Fig 13: Resultant state of a fabric dyed in an aqueous solution of *Allium cepa* after washing with laundry bar soap. Photo: Paul Aikhionbare, 2019

Experiment 5: Colour Fastness to Washing Test for a Fabric Dyed in an Aqueous Solution of Turmeric, and Washed with Detergent

Technical Details
Fabric Type: Cotton
Yardage: 1/2
Herb: Turmeric
Weight: 300g
Mordant: Alum - $XAl(SO_4)_2 \cdot 12H_2O$
Weight: 50g
Soap: Detergent

Procedure
The fabric to be tested was pre-dyed by soaking in the turmeric and alum solution for 45 minutes and cut into two equal halves. One half was put aside as control fabric, while the other was subjected to hand wash using detergent for about ten minutes (Fig 14). Thereafter, the washed piece of fabric was rinsed and placed side by side with the control fabric, for observation and visual analysis to ascertain the level of fastness to washing.

Comparatively looking at the washed fabric (Fig. 16) and the control one (Fig. 15), one can conclude that, like the *Allium cepa* dyed fabric, detergent is not suitable for washing turmeric dyed fabrics.

Fig 14: Washing of the fabric dyed in an aqueous solution of turmeric with detergent. Photo: Tova Aikhionbare, 2019

Fig 15: Specimen fabric dyed in an aqueous solution of turmeric Photo: Paul Aikhionbare, 2019

Fig 16: Resultant state of a fabric dyed in an aqueous solution of turmeric after washing with Detergent. Photo: Paul Aikhionbare, 2019

Fig 17: Washing of the fabric dyed in an aqueous solution of turmeric with laundry bar soap. Photo: Tova Aikhionbare, 2019.

Fig 18: Control fabric dyed in an aqueous solution of turmeric. Photo: Paul Aikhionbare, 2019 .

Fig 19: Resultant State of a Fabric Dyed in an Aqueous Solution of Turmeric after Washing with Laundry Bar Soap. Photo: Paul Aikhionbare, 2019.

Experiment 6: Colour Fastness to Washing Test for a Fabric Dyed in an Aqueous Solution of Turmeric, and Washed with Laundry Bar Soap

Technical Details

Fabric Type: Cotton
Yardage: 1/2
Herb: Turmeric
Weight: 300g
Mordant: Alum - $XAl(SO_4)_2{\cdot}12H_2O$
Weight: 50g
Soap: Laundry Bar Soap

Procedure

The fabric to be tested was pre-dyed by soaking in turmeric and alum solution for 45 minutes and cut into two equal halves. While one half was put aside as control fabric, the other was the experimental one subjected to severe hand washing using laundry bar soap for ten minutes (Fig. 17). The washed piece of fabric was then rinsed with water and placed side by side with the control fabric for comparative observation and analysis.

From a keen observation and visual analysis of the washed experimental fabric (Fig. 19) and the control fabric (Fig. 18), one could notice a minimal degradation of the dyed fabric after being washed with the laundry bar soap. Therefore, it can be deduced that turmeric dyed fabrics are not degraded when washed with laundry bar soap.

Conclusion

This study has been able to setup and execute six experiments to show colour-fastness in fabrics dyed with both *Allium cepa* and Turmeric, using alum ($XAl(SO_4)_2{\cdot}12H_2O$) as mordant. From the analysis of the experiments' results, general conclusions can be made. For example, all the experiments indicate quite clearly that alum is a good mordant for fabrics dyed with *Allium cepa* and turmeric, so long as the alum is boiled with the dye stuff for at least 30 minutes.

Again, the light fastness test resulted in very slight deterioration in the colour intensity, implying that *Allium cepa* has excellent fastness to light when applied on cotton fabrics. The light fastness test in the study clearly indicated a very slight fading of the experimental fabric, placing *Allium cepa* dye fixed with alum on grade 7 of Kiron's light fastness grade table - ascribing excellent fastness to light to it.

Also, the light fastness test on turmeric-dyed cotton fabric using alum as mordant indicated slight fading, which places it on grade 6 of Kiron's light fastness grade table - ascribing good fastness to light. In a clear way, the experiments indicate that detergents are generally not suitable for washing cotton fabrics dyed with either *Allium cepa* or turmeric dyes and fixed with alum. Detergent seems to be too harsh for these dyes. On the other hand, the study indicates that laundry bar soap is ideal for washing *Allium cepa* or turmeric dyed fabrics in which alum is used as mordant.

For colour fastness to washing test for fabrics dyed in an aqueous solution of *Allium cepa* and turmeric using alum as mordant, the study observed a slight degradation of the dyed fabric after being washed with the laundry bar soap. On the other hand, washing with detergent caused serious degradation. This implies that fabrics dyed with *Allium cepa* and turmeric are not susceptible to much degradation when washed with mild

soaps like laundry bar soaps. But they are damaged when washed with detergent. The experiments in this study indicate that natural dyes can have appreciable fastness to light and washing as exemplified by the dye extracts from *Allium cepa* and Turmeric. However, it is very important to note that fabrics dyed with *Allium cepa* suffered severe degradation when washed with detergent. But the degradation is very minimal with a mild soap. Thus, it can be deduced that naturally dyed fabrics should not be washed with detergent but mild soaps to avoid any form of degradation. With the growing preference for natural dyes, as Sangeeta (2015) suggests, there is a need for more studies on "natural dyes so that a formal documentation with all associated factors could be gathered".

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