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# The Role of Various Dyeing Auxiliaries in The Fastness Characteristics of Cotton Colouredwith Various Natural Dyes Through Pad-Steam Method (Part-I)

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## Abstract

This research project was carried to evaluate the colour fastness of cotton fabric some dyedwith natural dyes obtained from plant and applied on by pad steam method. Due to the rising trend of going “green” all over the world, the revival of natural dyes on textiles havebecome crucial. Dyes from natural sources show improved biodegradability and are mostlyenvironment ecofriendly. Their natural colouring substance is usually non-allergic, non- carcinogenic non-toxic, and non-hazardous to the user as well as environment. However, their non-uniform shades and poor to moderate colourfastness are some of the common drawbacks. In this research, dyes from alkanet root (*Alkanna tinctoria*), , madder root (*Rubia tinctorum*), cutch root (*Acacia catechu*), marigold flower (*Tagetes erecta*) and Turkey red (*Rubia cordifolia*) were used on cotton fabric. To appraise the prospect of improving their fastnessproperties, various dyeing auxiliaries have been incorporated in the dying formulas. Besides metallic mordants (alum, aluminium sulphate, potassium dichromate, copper sulphate, and ferric chloride), cationizing agents, finishing agents, crosslinkers and UV absorbers were applied by pre and post treatment techniques.

## Key Words:

Natural dye, alkanet root, cutch root, madder root, marigold flower, Turkey red, pad-steamdyeing

## Introduction

Colourfastness of a textile is one of the significant aspects in determining its serviceability. It is among the most important characteristic of the coloured objects which refers to resistance of colour to fade/alter in any features related to colour or degree of transference of its dye molecules to the attached white cloth and use circumstances or actions like wash, dry cleanetc. or contact with light, heat, etc. (Samanta & Konar, 2011). By employing sustainable natural dyes, better fastness properties of cellulosic fabrics could be obtained (Islam et al., 2020). Factors affecting the colourfastness include, molecular structure of dyestuff, fibre'schemical nature, the way of bonding of dye to the fibre. Similarly, the quantity of dye presentin the fibre i.e., shade depth, the use of dyeing auxiliaries in the dyeing liquor, and the actual circumstances prevalent throughout application. Fastness to light is affected by internal influences: the physical as well as the chemical state of dye, the amount of dye, the fibres, and the kind of mordant etc. (Cristea & Vilarem, 2006). Typically, a change in mordant even with the use of same dye result in producing different shade (Shariful Islam et al., 2020).

The revival interest of natural colorants has led to the scientific investigations and publications of new knowledge and research. These dyes are renewable, easily biodegradable, harmless and hold pollution-free wastes (Riaz et al., 2023). Numerous advantages make natural dyes an outstanding choice and a better substitute to synthetic dyes (Adeel et al., 2023). Research findings related to various sources of dyes, (Ratnapandian, 2013; Shahid et al., 2013), chemistry of dyes (Vankar, 2000; Vankar, 2013), extraction and method of application (Gulrajani et al., 2001; Mongkholrattanasit et al., 2010), fastness performance of these dyes and antibacterial/ antifungal treatments (Gupta et al., 2005) of natural dyes are now available.

Application of natural dyes and its fastness testing indicate some change of the colours of the dyed samples which involve several factors. This may be due to the decomposition of dye (Jothi, 2008) which leads to its conversion into differently coloured or colourless compound. Cotton fibre as well as most of the natural dyes has hydroxyl groups in their structure. It is the characteristic of these groups that they ionize under alkaline conditions. The use of mild and non-ionic soaps are therefore suggested to use for washing of natural dyed articles so as to avoid change of colour.

In the colouration of cotton fabrics with natural dyes, he application of metallic mordants are crucial as they have impact on the shade/colour produced from the process (Wanyama et al., 2010). The use of various mordants causes different colour hues (H), significant changes in K/S values as well as differences in lightness (L). The strength and stability as well as shade of dye on cellulosic material chiefly rest on on the kind of mordant designated and the fibre type. Considering the depth of shade, Ratnapandian et al. (2012), post-mordanting procedure as a better option as compared to meta-mordanting or pre- mordanting.

Beside the type of mordant, the amount or ratio of mordant with dye is also peculiar. The same amount of dye can take various optimum amount of mordant to produce dark shade.

Most of the available natural dyes generally need metallic mordants to enhance the dye affinity for particular fibre, thereby resulting higher colour yield, better fastness propertiesand variable shades. Examples of such metallic mordants are alum, copper sulphate and iron sulphate etc. (Nakpathom, 2012). However, their excessive use is harmful to consumer's health as well as environment because majority of these mordants are toxic in nature and therefore they should not be commercially employed.

Good fastness to rubbing, washing and light are desirable properties in dyed textiles(Ratnapandian et al., 2012). Improvement can also be made by treating dyed cotton fabricswith cationic dye fixing agents and UV absorbers (Grover & Patni, 2011; Hussain, 2012). UV- protection properties of fabrics are related to the composition, structure including weight,thickness, porosity, wave pattern, presence of pigments or dyes, dyeing auxiliaries etc. All these factors are able to decrease or prevent the transmission of UV-radiation. In a study toincrease the UV-protection and antibacterial activities (Ibrahim et al., 2010), the pre- mordanting step was found very promising for the development of protection properties against microorganisms and harmful UV-radiation. Most natural dyes have poor light stability (Lee et al., 2001; Samanta & Konar, 2011).

There has been a rising interest in the colorants from nature and their application on textile, nowadays. Extensive research work is being undertaken around the world on the natural dyes application. Maximum of these dyes have light instability (as compare to somefinest synthetic dyestuff). This is why the original shades of textile articles displayed in museum are mostly changed.Pertaining to the revitalization of these dyes, there is sufficient development but the current accumulated information is still inadequate for the natural dyes to use them on industrial scale. There is also a need to thoroughly investigate the environmental impact on the increased use and production of natural dyes. The recent trendof renewed interest in natural dyes for textiles have also provided opportunity to offer further scope for the development of other areas such as environmental science, biotechnology and textile technology etc. (Hill,1997; McCarthy, 1997). Mathematical modeling was employed by Faloppa et al. (2022) in order to apprise pad-batch technique for natural dye in colouring of cotton, compared to the exhaustion method. Padding technologies are predominantly valuable (Roy, 2019) for the application on products whichexhibit low dye affinity.

## Material and Methods

Medium weight, pure cotton fabric was prepared for dyeing with the aid preliminary processes. It was desized by formula having Bactosol MTN (Clariant Ltd) processed at 60 °C under pH 6-6.5, for 1 hour. Scouring was carried out by NaOH, wetting agent, Polyron (sequestering agent by Clariant Ltd) and detergent in the formula. All the constituents werehandled at 80-90 °C for 1 hour. For the formulation of bleaching treatment, hydrogen peroxide was utilized along with sodium hydroxide, Pentex GP (stabilizer by Clariant Ltd.).A continuous method of pad steam dyeing process (two bath-two stage) was carried out onselected natural dyes by using selected dyeing auxiliaries before and after the treatment.

For the purpose of investigation, the effect of various auxiliaries utilized in the application of these colourant, fabric samples were examined for wash (ISO 105-C06), light(ISO 105-X12), rubbing fastness (ISO 105-B02), and relative colour strength. Colour strength and other colour coordinates of samples were evaluated by Datacolor SF 600 spectrophotometer with software for colour measurement. Colour characteristics were measured as L*, a*, b*, C*, h° and K/S values of the coloured fabric samples.

## Results and discussion

Apart from dye, dyeing auxiliaries has their own distinct part to play in the colour fastnessproperties of cotton fabric. Data obtained from testing wash (staining on the adjacent whitefabric, change in shade), rubbing (both wet and dry), light fastness was cumulated and rearranged to study the role of every dye formulation in the use of natural dyes on cotton.

### The role of auxiliaries in the colour fastness

The record associated to the use of numerous mordants with plant based dyes is presentedby Figures 1- 5. Aluminium sulphate improved the cumulative colour fastness of alkanet and marigold flower to a great extent. It also managed to enhance the fastness properties of cutch and Turkey red dyed cotton samples. However, it could not play any appreciable role in thecolour fastness of madder dyed cotton.

Copper sulphate did a better job to assist marigold flower for increasing the colourfastness of cotton fabric. Considerable improvement was also brought about in the samplesdyed with alkanet, cutch and Turkey red. $FeCl_3$ was successful only with the combination ofdye formulation of marigold and alkanet. However, $K_2Cr_2O_7$ perked up when employed with all natural dyes except madder. The combination of alum and natural dyes in respect of colour fastness was suitable particularly with cutch (Fig. 4).

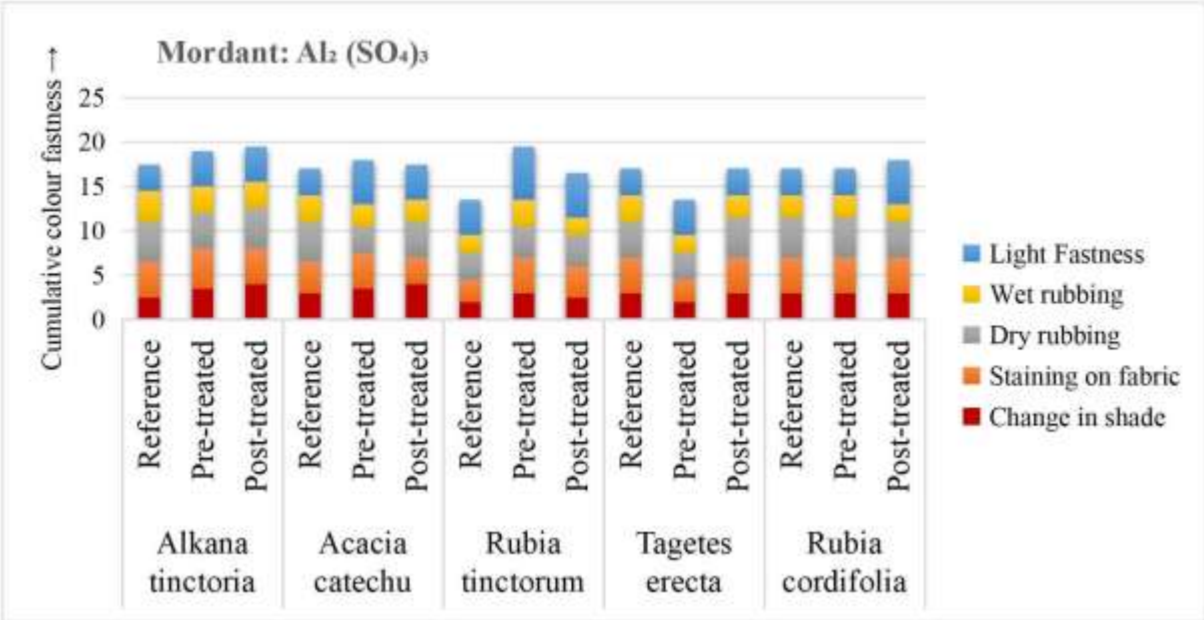


*Figure 1: Effect of $Al_2(SO_4)_3$ on the fastness properties (cumulative) of natural dyed cotton.*

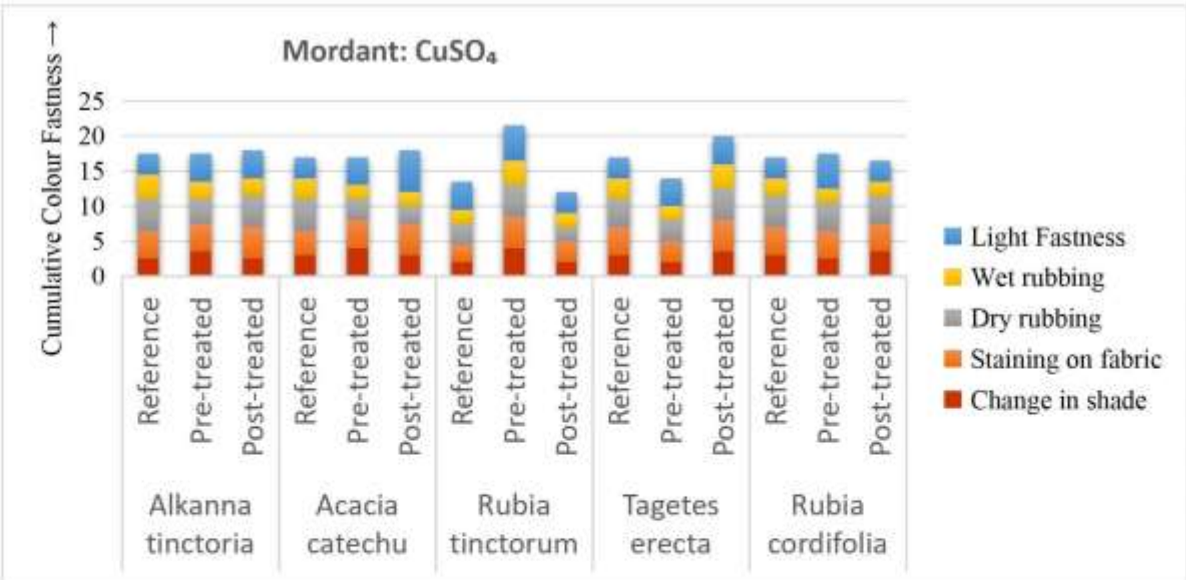


*Figure 2: Effect of $CuSO_4$ on the fastness properties (cumulative) of natural dyed cotton.*

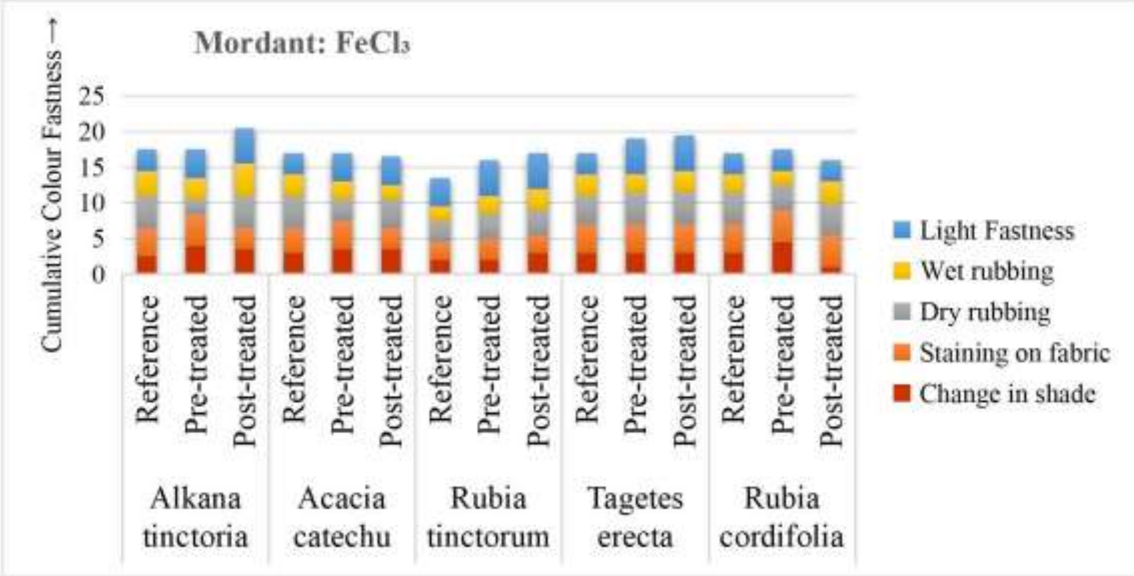


*Figure 3: Effect of $FeCl_3$ on the fastness properties (cumulative) of natural dyed cotton.*

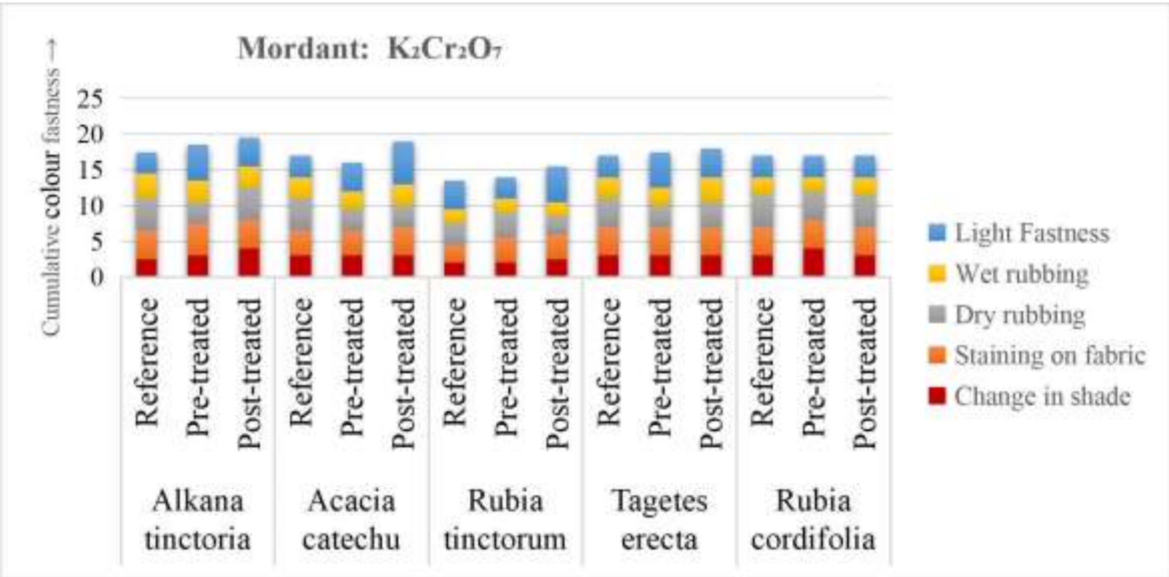


*Figure 4: Effect of $K_2Cr_2O_7$ on the fastness properties (cumulative) of natural dyed cotton.*

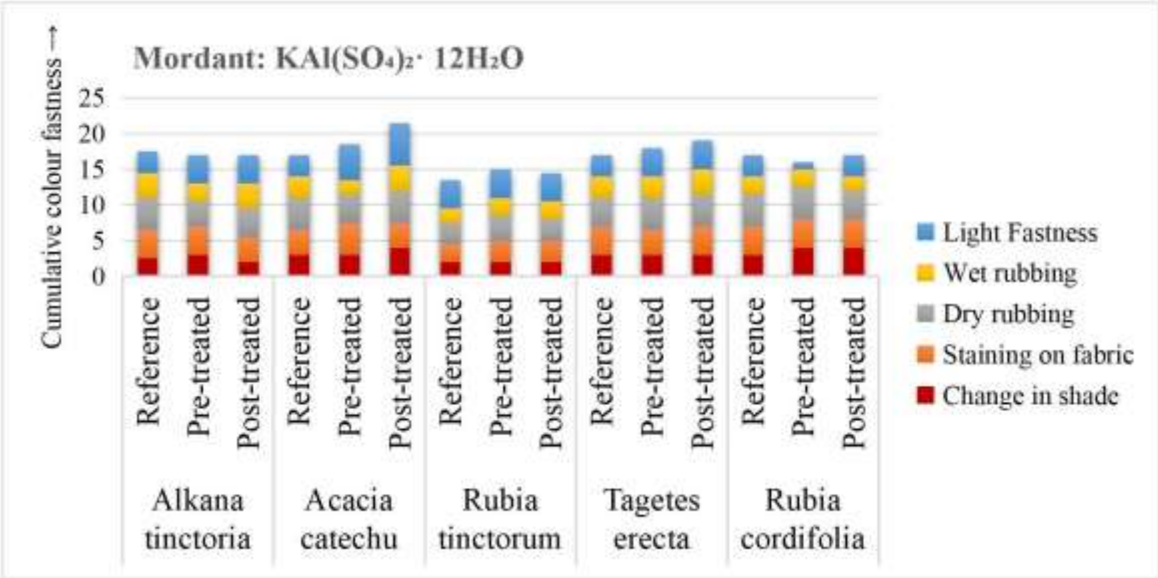


*Figure 5: Effect of KAl $(SO_4)_2.12H_2O$(alum) on the fastness properties (cumulative) of natural dyed cotton.*

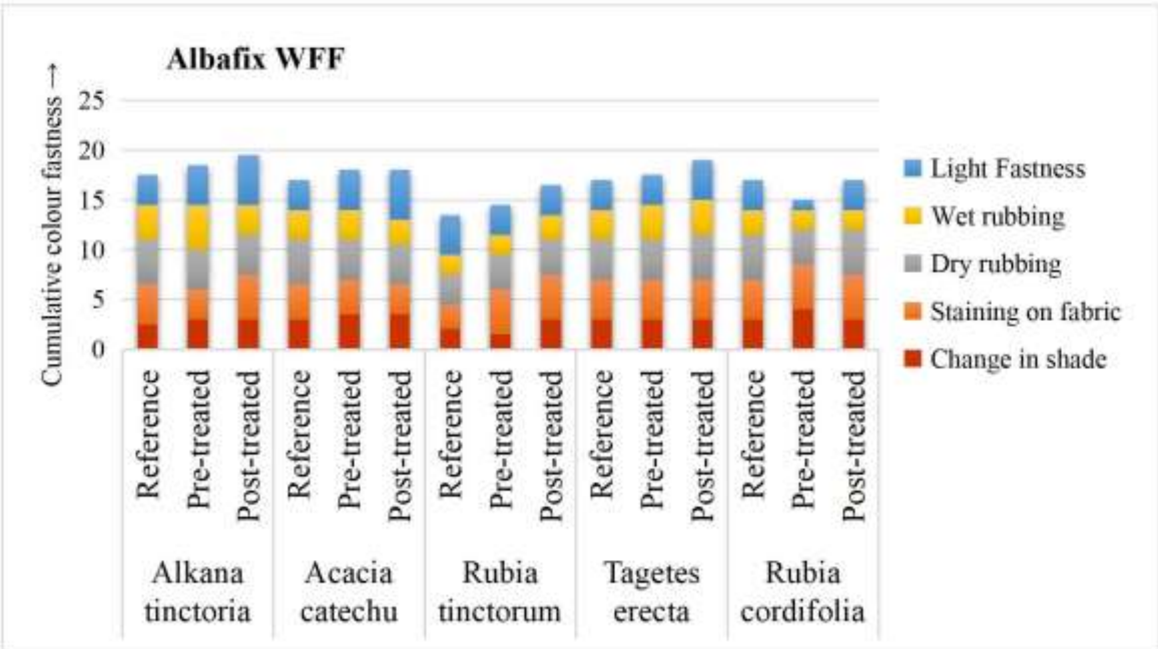


*Figure 6: Effect of Albafix WFF on the fastness properties (cumulative) of natural dyed cotton.*

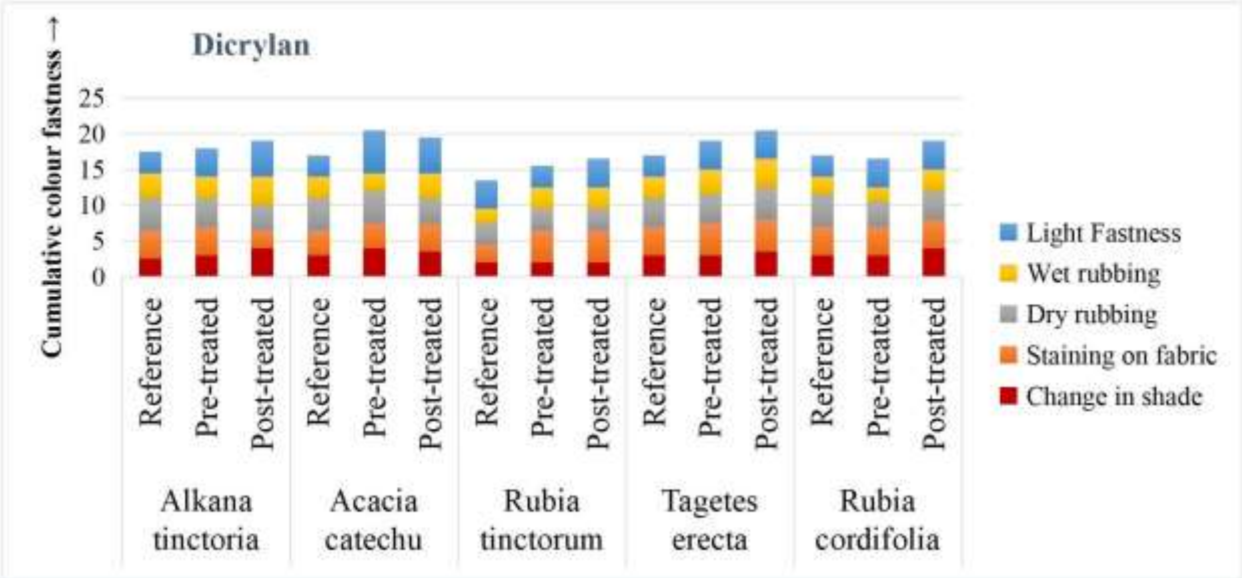


*Figure 7: Effect of Dicrylan on the fastness properties (cumulative) of natural dyed cotton.*

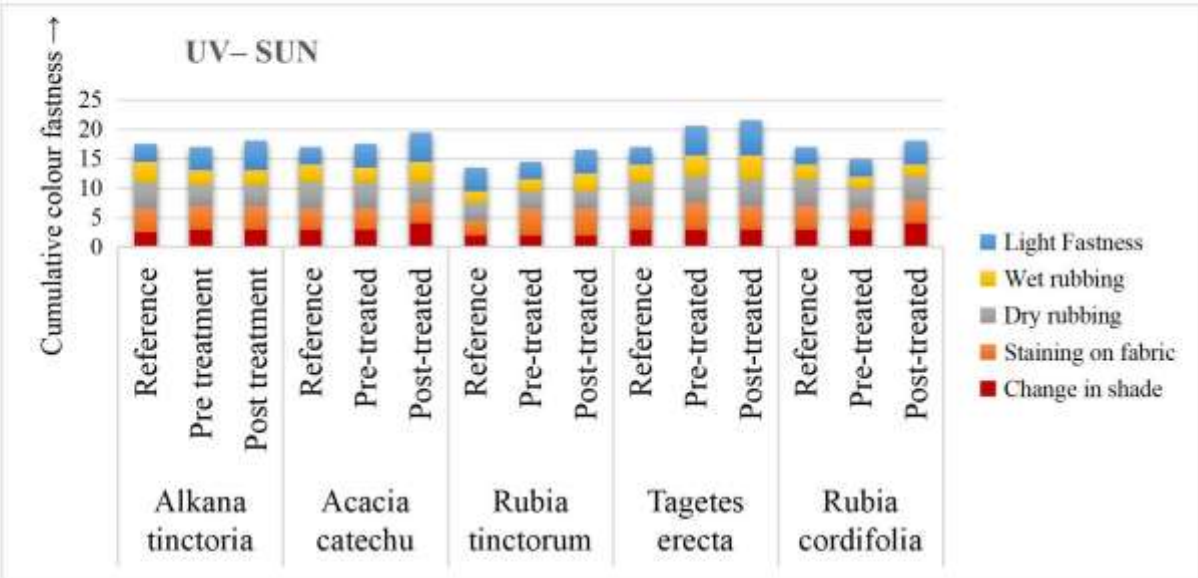

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*Figure 8: Effect of UV-SUN on the fastness properties (cumulative) of natural dyed cotton.*

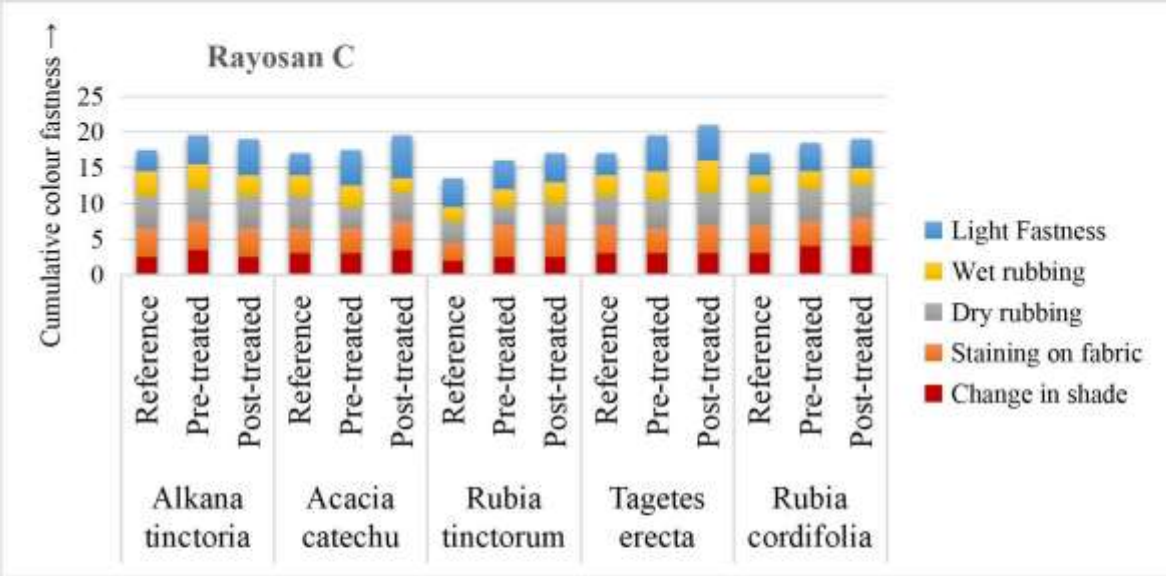


*Figure 9: Effect of Rayosan C on the fastness properties (cumulative) of natural dyed cotton.*

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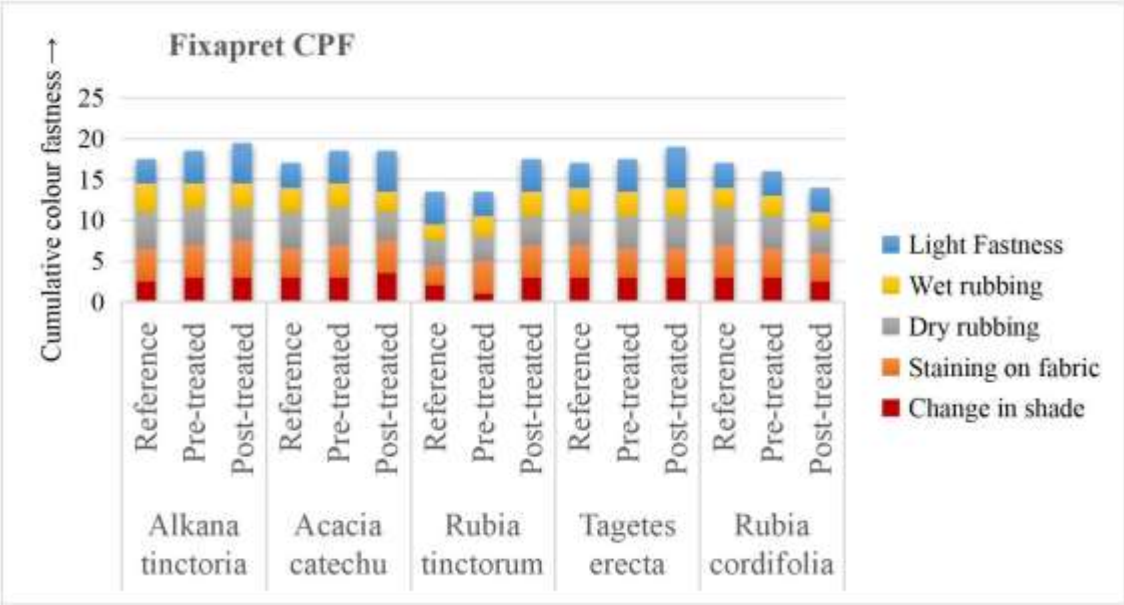


*Figure 10: Effect of Fixapret CPF on the fastness properties (cumulative) of natural dyed cotton.*

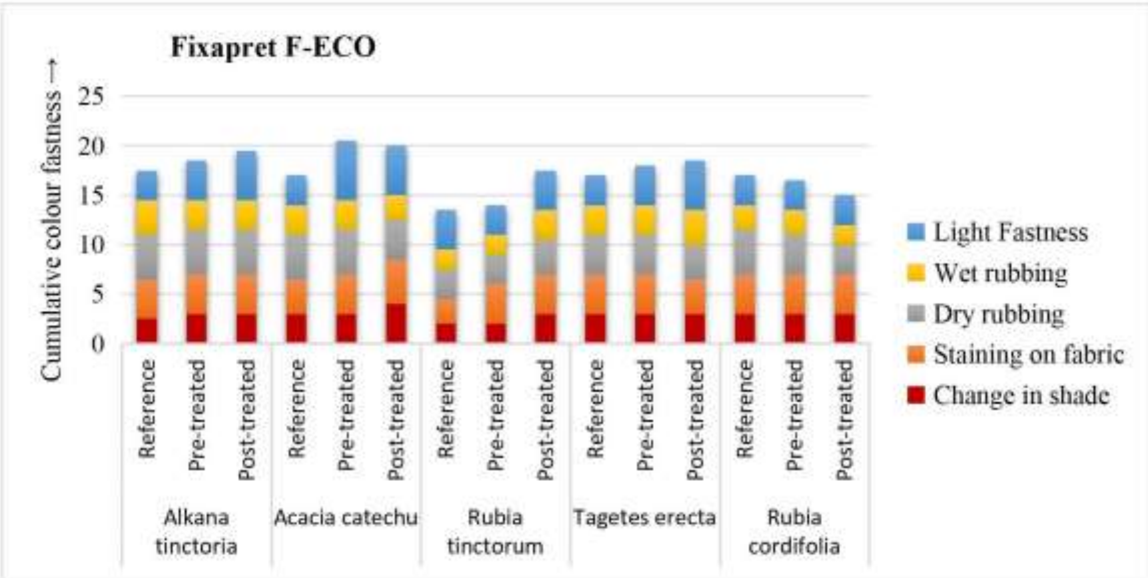

*Figure 11: Effect of Fixapret F-ECO on the fastness properties (cumulative) of natural dyed cotton.*

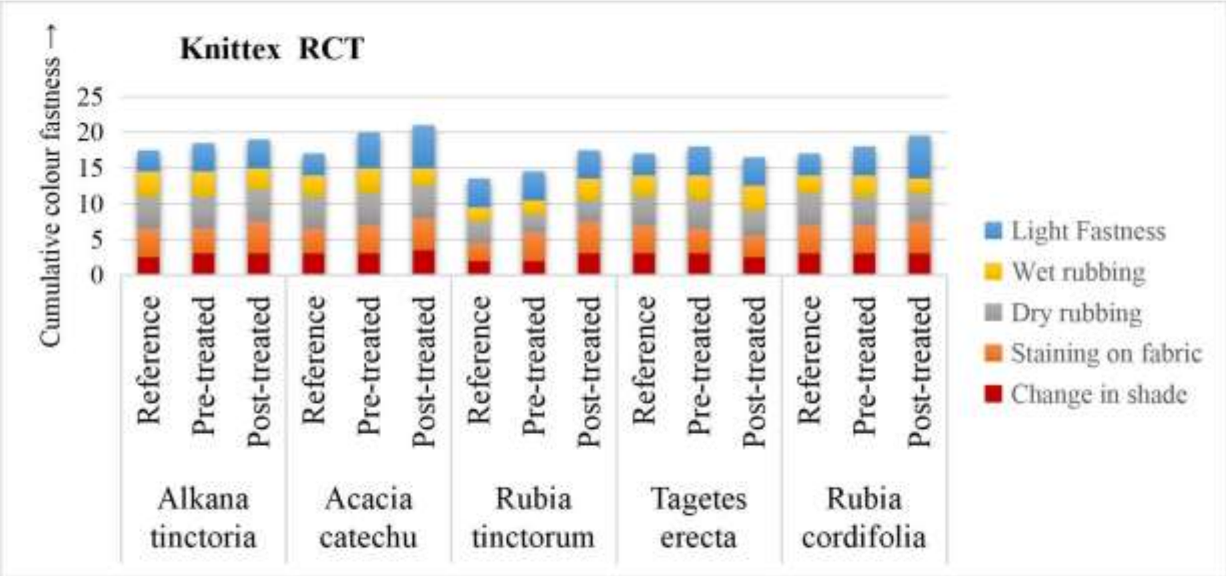


*Figure 12: Effect of Knittex RCT on the fastness properties (cumulative) of natural dyed cotton.*

Cationization of cotton proved more useful in revitalizing natural colorants particularly, dyeing with alkanet followed by both cutch and marigold in terms of increased fastness properties (Fig. 6). Dicrylan enhanced the colour fastness of cotton when it was used with cutch and marigold (Fig. 7). Similarly, both the UV absorbers, UV-SUN and Rayosan (Figs. 8 & 9) proved valuable when used with marigold in improving the colour fastness of cotton samples. Likewise, crosslinkers also made their way to boost up the colour fastness of cotton, dyed with natural dyes. In this regard, Fixapret CPF (Fig. 10) was responsible for increasing the colour fastness of alkanet dyed cotton and with a little difference, produced similar result with cutch dye on cotton. Another crosslinker, Fixapret F-ECO (Fig.11) also played its role in enhancing the colour fastness of cotton dyed with the same two dyes, but this time the colour fastness of cutch dyed samples was a little higher than the alkanet dyed cotton. Knittex (DHEU) showed the same performance and enhanced the fastness properties of cotton when applied with cutch root extracts (Fig. 12).

**Conclusion and recommendations**

The fastness properties presented by alkanet, cutch and marigold flower seemed sufficiently good for practical dyeing of cotton fabric. The beautiful and fast browns yielded by cutch oncotton are comparable with any high grade synthetic dye. Pad- steam dyeing producer haveresulted in better colour yielded and fastness as compared to conventional (exhaust) dyeingreported in the earlier studies particularly when dyeing was carried out on long runs.

Cationization and polyurethane emulsion have been satisfactorily successful in achieving the goal. Employment of UV absorbers with the application of natural dyes was a suitable option as they were found useful in the improvement of light fastness. The use of crosslinkers withnatural dyes on cotton showed successful results. They not only enhance the fastness properties but also maintained the shade yielded by the control sample. In this regard their use could be more practical in acquiring matching shades as compare to mordants which have produced their own district shade.

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