NATIONAL WORKSHOP AND SEMINAR

on

VEGETABLE DYE AND ITS APPLICATION ON TEXTILES

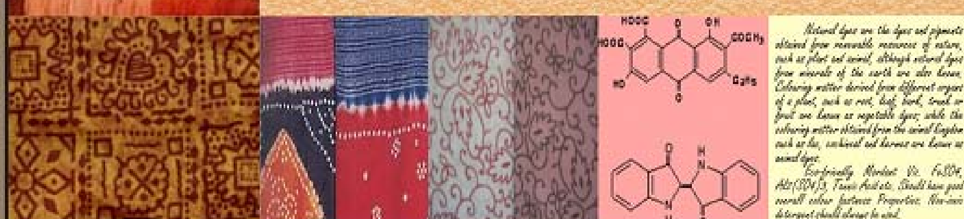
Organised

by

SILPA-SADANA

VISVA-BHARATI

2nd - 4th December, 2011



BOOK OF ABSTRACTS

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DEPARTMENT OF SILPA-SADANA
VISVA-BHARATI
Sriniketan – 731 236
District – Birbhum, West Bengal

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From the Desk of Head, Silpa-Sadana

In this juncture I become nostalgic. In our childhood, we used to pick a piece of charcoal or white clay and draw on the wall and floor to express ourselves. Secondly, I felt that not only my sitters but almost all the Indian-subcontinent girls have fascination to decorate their hand by ***Mehandi,*** *subsequently somehow we were unknowingly using the natural colour in the very beginning of our life.*

I remember Gurudev's word: ***"If we could free even one village from the shackles of helplessness and ignorance, an ideal for the whole of India would be established… Let a few villages be rebuilt in this way, and I shall say they are my India. That is the way to discover the true India (Tagore, 1928)".*** *Tagore's keen interest of upliftment of the rural mass, Indian craft sector have been considered as ancestor in the art of natural dyeing. So this workshop is a tribute to Gurudev on his 150th birth anniversary. But in India we are fortunate enough to preserve our age old tradition which is coming from Sindh (Pakistan), where a piece of cotton dyed with vegetable dye has been recovered from the archaeological site at Mohenjo-daro (3000 BC). India is supposed to be the oldest center of indigo dyeing. In India, there are more than 450 plants that have been recognized as dyes. Along with other dyes indigo was introduced to other regions through trade. Natural insect dyes such as Tyrian purple and Kermes and plant-based dyes such as woad, indigo and many other dyes were important elements of the economies of Asia until the discovery of man-made synthetic dyes in the middle of 19th century. Natural dyes have a renewable resource and contribute to rural economic development.*

In modern context, when fashion becomes an individual signature, naturally pigmented or dyed cotton can give the originality and uniqueness. Hence 5,000 years old knowledge of natural dyeing is reviving with new methodologies. There is experimental evidence to demonstrate this: naturally pigmented cottons have tremendous sun protection properties. It is hypothesized that the pigments in naturally pigmented cotton fibers are present to provide protection from ultraviolet radiation. Natural dyes produce an extraordinary diversity of rich and complex colours, making them exciting to use. Natural colours are great motivators and easy to design with. It is easy to design using natural colours as they complement each other well and rarely clash.

Natural dyes find its application in the colouring of not only textiles, but also it can be used in drugs, cosmetics, etc. Owing to their nontoxic effects, they are also used for colouring various food products. Since ages Indians are using turmeric and many other organic materials in our daily food. Globally, confectionery products containing natural colorants are growing. Globally confectionery market has moved more aggressively towards natural colors increasing from 5.5% of total product launches in 2006 to a projected 12% of total product launches in current year. From prehistoric period, people used natural dye for their painting; many cave paintings are the example of this viz. Atamira, Bhimbatic ets. Recent year use of natural colour in color photographs or color transparencies is still in the initial stage of application. In present scenario of sustainable design, eco-friendly is the buzzword, and carbon footprint becomes the one of the essential parts of our production system. Hence we should give more emphasis on developing naturally dyed products.*

The proposed workshop and seminar on "Vegetable dye and its application on textiles" being the outcome of continuous research and developmental activities carried out at Textile Section, Silpa-Sadana. This workshop and seminar will benefit entrepreneurs, textile designers, handloom dyers and printers, the craftsmen, academician and the personnel connected with this trade. The outcome of this workshop and seminar will enhance our age old tradition with the help of modern technology.

****Search is only based on the use of US exempt colors, not those that may be considered naturally derived in each respective country.***

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From the Organisers' Desk ………………….

Silpa-Sadana is the pioneer Institution under the aegis of Visva-Bharati, a central university, for imparting technical education in the domain of cottage and small scale industries since its inception in 1922. The great poet and philosopher "Gurudeva" Rabindranath Tagore, founder of Visva-Bharati, had the dream of rejuvenating the traditional knowledge and to flourish it with a view to socio-economic upliftment of rural people. Craft sectors had been given the top most priority. Later the great son of the great poet, Rathindranath devoted his entire life to turn his father's dream into reality through his indefatigable and enervated efforts. To fulfil this mission, of course, he was backed by the active assistance from his wife, Pratimadevi, who stretched her arms in this noble venture. Through their continuous research and endevour, Silpa-Sadana, in due course, became the Cottage Industries Training Centre and the produce from its extension wing emerged out as the trend setter in design throughout the country.

It is a great pleasure and pride on our part to walk down the path shown by Rathindranath and Pratima Devi. Imparting teaching and hands-on training, organisation of symposium & workshop, etc. are always given the prime importance to disseminate knowledge from college to cottage. This time, to organise a ***National Workshop and Seminar on Vegetable dye and its application on textiles',*** *is another endeavour from our part to carry forward the vision and fulfil the mission of "Gurudeva". The theme of this programme is very relevant and time demanding, especially in the present scenario of growing consciousness of greener environment. Mutual exchange of views, scientific understandings, and innovations in the field of dyeing and design concepts are the main motto of this program likely to be beneficial for the whole gamut of esteemed participants coming from all arena.*

Content

Silpa-Sadana ——— past and present

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Introduction

The department of Silpa-Sadana (erstwhile Shilpa Bhavana) has been playing a pivotal role to carry forward the dream of Gurudeva Rabindranath Tagore of acquiring the economic self-sufficiency to the underprivileged rural community of India for decades. Rathindranath Tagore has given the shape of Gurudeva's vision through establishing Cottage Industries training Centre (now popularly known as Silpa-Sadana). It is the craft wing of Visva-Bharati and one of the oldest Technical Institution of India. Silpa-Sadana has a long tradition in the production of innovative & artistic handloom and handcrafted products and, hence is well known for its Technical training and exquisite craft based products in cottage industries & craft since its inception. It was set-up in 1922 as an integral part of Gurudeva's Sriniketan experiment of rural reconstruction.

Why Silpa-Sadana was formed? ——— the idea behind and its contribution

Its mission was:

- To revive & revitalize the dying craft sector through cultural reawakening.
- To develop craft as an industry and alternative mode of livelihood in the villages.
- To turn out functional products with artistic & cultural sensibilities for the local and export market.
- To impart the required technical training for creating appropriate opportunities and achieve economic self-sufficiency for craftsmen in the villages.

It had taken a leadership role in reviving and revitalizing the rural industries and craft sector, in particular, for sustainable economic regeneration of the villages. It occupies a unique position among the technical institutions in having been able to revitalize the decadent cottage industries by those artistic and creative impulses which underline the principle of 'Functional beauty', the foundation of all indigenous hand crafted articles. It had reoriented and reengineered this sector by introducing innovation in technique, technology, aesthetics and design through better craftsmanship, new skill, new design, new trade, better techniques, and upgrading methods of production and infusing design elements from other culture. The efforts oriented towards this direction gradually spread not only in the surrounding villages but also throughout the country. Thus a professional attitude at Silpa-Sadana has gradually evolved through the decades coupled with aesthetic finesse. Even today, the craft articles made at Silpa-Sadana stand out for its excellence and unique aesthetic appeal. Its linkage with the villages surrounding the university provided stimulus to such entrepreneurial activities. Over the years Visva-Bharati could position itself as a pilot hub and pedagogic nucleus for spreading creative and cultural industries in and around its vicinity.

Santiniketan product style: identity and quality

Among other things it could create a distinctive stile of its own. The products made at Silpa-Sadana became very popular within a very short period because of their uniqueness. Quality of craftsmanship was evident right from planning, designing up to the stage when the finished product emerges. And an Identity of the products made was finally achieved through its design idiom with a distinctive brand name known as Santiniketan Crafts. This has undoubtedly made its due share of contribution both to the domain of culture and commerce. These products still convey a living tradition belonging to Santiniketan. Recently, the government of India has identified the artistic Leather goods of Silpa-Sadana (an innovative product style introduced by Rathindranath Tagore) as an original product-style and registered the method as Geographical Indication Mark in the name of "Santiniketan Leather Goods". Craft and creative activities have now become a culture of this place and the efforts gradually spread not only in the surrounding villages but also throughout India.

Technical training in its initial days

Though it is a pioneer institution and has sound track record in running technical training as well as business activities simultaneously in various trades under the same roof for the benefit of underprivileged mass, but its business side was never considered as the chief concern. The emphasis was more to run the centre on Institutional basis rather than a commercial one (vide Visva-Bharati's Bulletin no. 32, January 1951 written by Rathindranath). Gradually Handloom Weaving, Wood Work, Pottery, Cane & Bamboo, Lacquer-work, Handmade Paper, Basketry, Toy Making, Bakery, Book-Binding, Printing, Leatherwork, Embroidery, etc. were introduced.

Initially full-time apprenticeship based training programme in different areas were designed for creating skilled manpower in the respective discipline. Training cum production activities in the area of Wood Work, Leather Work, Handloom Weaving, Electro-Mechanical Engineering, Dyeing & Printing, Hand Made Paper Making, Pottery, Basketry, Lacquer-Work, Toy Making, Bakery, Book-Binding, Embroidery etc. were introduced. Linkages with the nearby villages were established. Energetic young people from the nearby villages were inducted in the training programme. Traditional cast-barrier in practicing leatherwork was removed for the first time in India. Candidates from all over India joined the training programme. Trainees were given freedom for innovations. They used to earn after one-year. Imparting formal technical training in various field of cottage industries and craft disciplines was given due consideration after Visva-Bharati became a Central University in 1951. It has been offering job-oriented professional and vocational courses in various craft disciplines at different level (Short-term casual course, 1-year Reorientation course; Two-year certificate course after class-VIII; Special craft course at school level: HS & School final level and 3-Year diploma course after class X) since then.

Present situation

Infrastructur

New campus

Silpa-Sadana is one of the oldest institutes of Visva-Bharati, a central university. Most of its infrastructural facilities are backdated. Planning to update these has been done. In the 11th Five-year Plan period about rupees twelve cores has been allotted to Silpa-Sadana for building a new campus including studios & workshops. The construction work is in full swing. That is why the department is facing some difficulties in carrying out its activities in this stopgap period.

Activities

Presently Silpa-Sadana has three broad divisions: i) Technical training, ii) Production and Extension to offer necessary assistance to the trainees, trained personnel and skilled craftsmen from the adjoining villages to produce craft articles on behalf of the department on contractual basis, and iii) Marketing Wing to sell its produce. The products made are sold mostly through its only Sales Emporium located at its Sriniketan premises and also through its annual sales counter put up at " Poush-Mela", " Magh-Mela " and " Rathindra Silpa Mela".

The different sections under Silpa-Sadana for conducting the above mentioned activities are as under:

A. Textile (comprising weaving, dyeing & printing).
B. Wood Work (comprising training & production unit).
C. Pottery-Ceramic.
D. Handmade Paper.
E. Artistic Leather Work.
F. Batik Work.
G. Computer & Photography.
H. Seminar-Library.
I. Office & Sales Emporium.

Present training progamme

New course

The three 3-year diploma level Technical courses namely i) Diploma in Textile Technology Handloom; ii) Diploma in Pottery & Ceramic Technology, and iii) Diploma in Furniture Technology & Interior Design have been upgraded to 4-year professional Bachelor in Design (B. Des.) course and introduced from the academic session 2010-'11.

Existing courses

Silpa-Sadana presently runs the following professional and vocational courses (degree, diploma, certificate & short term casual courses) from its premises:

Training Programme	Intake capacity (in Total)
A. Bachelor in Design (B. Des.) with specialization in: i) Pottery-Ceramics & Lifestyle Products ii) Furniture & Lifestyle Products iii) Textile & Accessories	36
B. Certificate courses: in i) Wood Work, ii) Handloom Weaving, iii) Pottery-Ceramics, iv) Artistic Leather Craft, v) Batik Work, vi) Handmade Paper Making	54
C. Short Term Programmes in Indian Craft Techniques	Need based

Existing staff pattern

Category / Description	Textile	Wood Work	Pottery Ceramic	H. M. Paper	Batik	Leather	Book Binding	Office	Emporium	Total
A. Teaching										
1.Professor	-	1	-	-	-	-	-	-	-	1
2.Associate Professor	2	--	-	-	-	-	-	-	-	2
3. Reader	-	-	1	-	-	-	-	-	-	1
4.Assistant Professor-II	4	1	2	1	-	-	-	-	-	8
5. Assistant Professor-I	1	5	2	-	-	-	-	-	-	8
5.Instructor	-	-	-	-	-	-	1	-	-	1
B. Technical										
1.Supervisor/Instructor / Storekeeper	1	1	-	-	-	-	-	-	-	2
2.Demonstrator	-	1	-							1
3. Technical Asst.	1				1					2
4. Head Mistry/Asst. Dyer/ Machineman	1	2								3
5. Helper/Labour	-	1								1
C. Office Staff										
1.Sectional Officer	-							1		1
2.Office Asst/Typist / Cashier								2	2	4
3.Peon/Attendant		1						3	1	5
D. Part time Staff	1	-	-	-	-	1	-	-	-	2
D. Casual Labour										
1. Skilled Workers	2	4	1	3			10			20
Total (Section Wise)	13	17	6	4	1	1	11	6	3	**62**

Rathindranath Tagore and his contribution towards rural socio-economic development

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Abstract

Rathindranath Tagore was the most representative product of Rabindranath's educational ideal. He had the various intellectual outputs on the different fields. The paper explores the intellectuality of Rathindranath Tagore from the various points of view. He was an ideal teacher, scientist, social reformer, a good administrator and an artist as well. He remains within us as a natural lover also. In this paper, the author also highlighted the contribution of Rathindranath Tagore towards socio-economic development at Sriniketan.

***Keywords*:** Batik, Rathindranath Tagore, Socio-economic development, Sriniketan.

Introduction

Before going to the main discussion, let us have a glimpse on the short biography of Rathindranath Tagore, the eldest son of the great poet, Rabindranath Tagore and Smt. Mrinalini Devi. Rathindranath was born on 27th November, 1888 at *Jorasanko Thakurbari* in Kolkata and spent his childhood at *Jorasanko* and then at Santiniketan. His education primarily started at home like his father, and subsequently he was enrolled in *Brahmacharyasram* in 1901. He was a student among the five of the first batch of the *Ashram*. Rabindranath Tagore decided to send him to Illinois University, America to study agricultural science after the completion of his school education at Santiniketan. He stayed there from 1906 to 1909 with an ambition to develop village economy, preservation of heritage, education of science, and Art & Culture at Santiniketan as well as at Sriniketan. During his stay in America, he took keen interest in various aspects of tangible and intangible culture. He established *Cosmopolitan Club* in his University, which was actually a centre of acculturation of foreign students. This Club became very popular in different western countries. Dr. Arthur R. Simour, an eminent teacher of Latin language and literature in Illinois University, also inspired him to develop various activities of the club. Ultimately, this club turned into an association of International Club, and Rathindranath Tagore became the founder president of it. In 1910 he married Smt. Pratima Devi and travelled various countries to take an account on the development of Science, Art and Culture. He accompanied his father in different foreign tours viz. America (1912), England (1912 and 1926), Holland (1926), France (1926), Germany (1926) etc.

Rabindranath established Visva-Bharati in 1918 and subsequently Sriniketan Campus in 1922 with the active assistance from Rathindranath Tagore. After the demise of Rabindranath Tagore in the year 1941, Rathindranath suffered a set back due to acute financial crisis, and the developmental work came to a grinding halt [1]**.** Rathindranath spent the next four decades of his life serving Santiniketan, Sriniketan and Visva-Bharati, and played a catalytic role towards the establishment of Visva-Bharati as a Central University. Finally, Visva-Bharati became a Central University by the Act of the Parliament in 1951 and

Rathindranath became the first Vice-Chancellor of the university for the period of six years. He took all-out initiatives for the betterment of Santiniketan, Sriniketan, and Visva-Bharati as a whole. He died on 3rd June, 1961 during the year of birth centenary celebration of Rabindranath Tagore. He remains within us as a creative painter, photographers, craft artist, teacher, writer, architect, horticulturist as well as agriculturist —— all in one.

Rathindranath as a teacher and scientist

Rathindranath was an inborn scientist, and from the inception of Visva-Bharati he had taken up the responsibility of science education and also introduced hands-on demonstration methods for easy understanding. Since there was no science book in Bengali language in India at that time, he wrote some books viz *'Prantatta' (1348*), *'Abhibakti' (1352*) etc.[2] in the field of agriculture. He had also produced different hybrid vegetables to increase production rate, which was a commendable work during that period. Eighty to Ninety years back Rathindranath Tagore carried out experiment on different plants and produced several types of fruits, vegetables, flowers etc. which were grown naturally in the unfertile soil like laterite soil of Sriniketan. According to his technique, the poor farmer can cultivate crops in unfertile land of Birbhum, Purulia, West Midnapur etc. with the help of the professionals. *Guhaghar*, the workshop of Rathindranath Tagore is just like a laboratory of a scientist. On one side of a column different tools and instruments are arranged, and the wood block sample libraries with scientific names are arranged on another portion. The layout of original sample soil layer of Santiniketan, wooden floor, basin, light, rest room etc. are just like an ideal science laboratory.

As a social reformer

Apart from teaching science subjects, Rathindranath demonstrated the methods of dyeing (batik work) of textiles and leather, wooden crafts, ceramics etc. so that the illiterate people of rural areas can easily understand and adopt those techniques. According to the instruction of Rabindranath Tagore, he established a *Jana Hitayishi Shava* to promote different cottage industries and to develop economy at Patiswar, Silaidaha, Kaligram, Kustia etc. That *Shava* established few schools, health centre and also organised different discussions to educate rural masses about good qualities woodcraft, ceramics, textiles etc. for the development of their economy as well as to develop good relationship between Hindu and Muslim community. Rathindranath perfectly utilized those experiences for the devolvement of Silpa-Sadana later on at Sriniketan.

As a good administrator

Rabindranath and Rathindranath Tagore used Sriniketan Campus as an experimental laboratory for the development of cottage industries. Rabindranath Tagore during his world tour accumulated different interesting ideas which helped him establish different cottage industries for the villagers, and advised Rathindranath to apply those ideas at Sriniketan and at Silpa-Sadana (previously known as Silpa-Bhavana), in particular. The effect of the employment provided by Silpa-Bhavana on the economy of the adjoining rural areas had been very considerable in those days. Elmhirst and Surendranath Kar had also played a great role to promote Sriniketan. During Java and Bali visit of Rabindranath Tagore, Surendranath Kar accompanied him and he studied batik work on textile in details by using different tools and equipments. In 1927 he and Rathindranath imported few tools and equipments (Tjantings), and at Sriniketan and Kala-Bhavana they introduced batik handicraft which was very easy and more applicable for rural sectors with the help of Nandalal Bose and the students of Kala-Bhavana [3]. During that time, there was no skilled weaver at Sriniketan locality to produce quality textile. However, only a few non professional Mohammedans at Sriniketan area used to produce very course and inferior variety of textiles. To solve those problems Rathindranath employed a person from Serampore to teach modern techniques of weaving that helped enhance the textile cottage industry at Sriniketan [1, 3]. During his medical treatment in England in the year 1928, he was impressed on the batik work on textile and leather. After that he and his wife Smt. Pratima Devi made an in-depth study on leather batik and imported all the vital tools, equipments and colours. Rathindranath and his wife established a school at Patiswar with the financial support of 'general fund' that he created earlier to educate the poor villagers thereby making them financially self sufficient, and later on at Sriniketan the same model/idea had also been implemented. Rathindranath also sent Smt. Pratima Devi to Paris to learn batik work so that the product quality of Silpa-Sadana and Kala-Bhavana improves further [3].

As an artist

As a painter, he created different kinds of paintings i.e. flower study and landscapes. His flower study was about expressions of scientific mind, but application of colour and style was like original. Rathindranath, generally, did not mention any date in his painting except a very few. His oldest painting was in the year 1928. We can find the style and elements of Impressionism Art in the paintings of Rathindranath. During this time Abanindranath started the movement of Indian traditional style of painting. But in case of landscapes and wooden inlays, Rathindranath was influenced by his father. There are only 52 paintings of Rathindranath in the collection of Rabindra-Bhavana. His others paintings remain scattered among the Rabindra Bharati Society, Rabindra Bharati University and in other private collections. His artistic sense and aesthetics not only helped him design wooden inlays, ceramics materials, and textile prints etc. at Sriniketan but also influenced to set up small scale industries in the rural areas. The planning of Uttarayan Garden, Pampa lake and different buildings like Udayana, Chitrabhanu, Guhaghar, creation of wooden furniture and crafts etc. are the examples of his artistic expression. He imported different tools and equipments to create enormous wood crafts, wood inlays etc. The modern craft artists followed him to create exclusive art objects. Stela Cramrish rightly says "*Rathindranath Tagore is a maker of form. To the art of India of today he gives back the dignity of its craft out of the store house of his mine he shapes the order of things and their fitness. He carves objects from many woods and paints the portrait the many flowers. His works does not belong to any school. Self-taught and straight forward it follows the disciplines of first principle and applies there with tenderness of precession to small objects and pictures*" [4].

As nature lover

In this context, it may be worthy to start with a line of Rabindranath Tagore --------
'বাতাস জল, আকাশ / সবারে আজি বাসিব ভালো / হৃদয় সভা জুড়িয়া তারা বসিবে নানা সাজে ....'
As early as in 1896, Rabindranath Tagore urged for the restoration of our natural forest resources [*dao phire se aranya, lao e nagar*]. Rabindranath Tagore, as a thinker, was totally against the introduction of rampant mechanization of human activities and also expressed the ill effects of this industrialization on the natural landscape as well as on the society at large. Rathindranath Tagore was also influenced by his father and rightly emphasized on the protection of plant cover and on the need for adopting adequate measures for conservation of natural resources. He made gardens and different buildings at Santiniketan in an eco-friendly manner, and developed different cottage industries by using different colours derived from plant sources [5]. During that time natural colours e.g. turmeric, burned marble stone and animal shell (CaO or *chuna*), different leave extractions and different mineral dusts were commonly used for the colouration of textiles and *patachitras* in rural Bengal. Those dyes were less bright but economical and good for health [6]. He also encouraged rural people to follow traditional methods. Now with the advent of modern technology, natural dyes are becoming brighter but costlier than its synthetic counterpart. So it is a challenge to popularise the natural dyes and the products made out of it among the common people.

Conclusion

The development of cottage industries and crafts has always been one of the main aims of the comprehensive scheme of education envisaged by Visva-Bharati since its inception. During the financial crisis of Visva-Bharati from 1922 to 1950, the Sriniketan Campus including Silpa-Bhavana was profitable due to its scientific management and the restless effort of Rathindranath Tagore. Only in the financial year 1949 – 1950, the output of Silpa-Bhavana was Rs. 237897.00 (two lakh thirty seven thousand eight hundred ninety seven only) [7]. His contribution especially in the field of art and craft, culture, cottage industries and as a social reformer has not yet been properly assessed. So it is important to study and analyse the contribution of Rathindranath Tagore in the field of art and craft, culture, cottage industry, and also his involvement and participation in the growth and development of the education in India as desired by *Kabiguru*. Rathindranath Tagore assessed himself in a single sentence as follows:

"জন্মেছি শিল্পীর বংশে, শিক্ষা পেয়েছি বিজ্ঞানের, কাজ করেছি মুচির আর ছুতরের"

(*Janmechi silpier banshe, sikha payechi bigganer, kaj korechi muchi ar chhutorer*)

References

1. 'Tagore *Rahthindranath, Janma Satabarsa Purti–Sadergha'*, Visva-Bharati Granthana Bivaga, Kolkata, 1988.
2. *Tagore Rathindranath*, 'On the Edges of Time', Visva-Bharati Granthana Bivaga, Kolkata (1958).
3. *Tagore Rathindranath, 'Pitri Smriti'*. Kolkata:Jigasa.(In Bengali), (1973).
4. *Kramrish, Stella*, 'Introduction' Tagore. New Delhi: All India Fine Arts and Craft Society, (1948).
5. *Mandal, P. K,* "*Rabindra-Bhavana Sangrahasala, Santiniketan"*, (Bengali). Journal of the Dept. of Museology, University of Calcutta, Vol. 4, (2005),
6. *Mandal, P.K*, "Patachitra in Bengal: An Intangible Heritage", Journal of Museums Association of India, 24 (2004).
7. Visva-Bharati Bulletin, No. 32, January, 1951.

Acknowledgement

Author wishes to acknowledge Sri P.K. Mandal, Rabindra-Bhavana, and Sri Tapas Kumar Das, Central library, Visva-Bharati. Last but not the least, the author also acknowledges Smt. Susmita Roy Maulik- for her inspiration assistance while writing this article.

Innovative dyeing and printing with natural dyes

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Abstract

The whole world is deeply concerned about global warming which may cause severe disaster in due course if proper precautionary measure is not taken right now. Global warming is due to increase of Green House Gases (GHG) produced mainly from power plants, big industries, auto vehicles, small and cottage industries and even domestic activities where fuels like coal, diesel, petrol and wood are used regularly. Deforestation is another reason of global warming as trees and plants are the consumers of carbon dioxide evolved from different fuels. 'Carbon Foot Print' is the total set of Green House Gases consisting of chlorofluorocarbon, methane and nitrogen oxide apart from carbon dioxide which remains in the highest percentage and is responsible for maintaining the atmospheric temperature. Foreign textile buyers are now emphasizing on carbon foot print especially on natural color products that deserve to be really eco-friendly as well as environ-friendly. The small work done here aims this noble vision to encourage other industries of different sectors to keep an eye to their products which should not affect the Green House Effect (GHE).

***Keywords*:** Carbon foot print, Global warming, Green house gases, Green house effect.

Introduction

Use of natural dyes on Textile material has become very much popular throughout the world due to its eco-friendliness, environ-friendliness, ancient heritage and aesthetic approach. Since 1990 till date so many research workers are giving their enormous efforts behind searching different new sources and different methods of application. But still then, the age-old conventional methods like premordanting, post mordanting and simultaneous mordanting can not be avoided. Now the foreign markets, who are giving much importance to the natural color dyed eco-friendly products, are emphasizing also on "carbon foot print" which is now a very important factor for green house effect. Carbon foot print has a vital role with advancement of civilization of the world and continuous growth of industries. The main green house gas i.e. carbon dioxide has become increased to a large extent in various ways causing global warming. Textile industries are one of them, which cause emission of carbon dioxide gas during operation of big boilers fired with coal or diesel. Even big power plants and some small industries are also responsible due to use of huge amount of coal, wood and other waste cellulosic materials that produce carbon dioxide gas. Global Warming is a warning of a severe disaster, which may of cause destruction of all our civilization. Hence it is high time to think in each and every sector to use fuel as least as possible to sustain the level of carbon dioxide normally utilized by trees and plants and simultaneously to maintain an optimum level of oxygen percentage for the benefit of all living beings [1].

The Theme of the Work

Environmentalists throughout the world are looking at strategies for reducing carbon footprint. By this small but novel project, loss of GHG balance occurred during natural colour dyeing and printing is tried to be reduced. This work has been done specially for the small scale and cottage sectors by taking an attempt to avoid the use of fuels where and when possible. The product in such process is also compared with the product in conventional process. The parameters for testing are here kept limited only on washing fastness and rubbing fastness as light fastness is an inherent property of the dye but not on the method. More over the parameters like depth, brightness and evenness of shades are visually examined. But in both the cases number of use of fuel with total time is taken into account. Application of such new method is done both on cellulosic and protein fiber to have a comparative study of the result.

Materials and Methods

The experiments have been done by using grey handloom 100% cotton fabric and mulberry raw 100% silk fabric. Mainly two salts namely, Aluminum sulphate and Ferrous sulphate have been used as mordants. Non-ionic wetting agent, acetic acid and gum Indulka have been used as chemicals and reagents of commercial grade.

The dyes used are Lac (Laccaica extract) and Terbula (Harda extract) which are obtained from natural animal and natural vegetable sources respectively. The dyes are all in dense liquid form manufactured by Eco-N-Viron, a newly growing natural colour manufacturer of West Bengal. The Fuel and heating device used in this work are LPG gas and gas burner respectively.

Methodology

Preparation of the fabric

A piece of 100% grey cotton fabric and a piece of 100% raw mulberry silk have been taken for this experimental work. Standard process of combined scouring and bleaching for cotton fabric has been adopted. Silk fabric is degummed and bleached following a standard method in the same bath to save fuel. Temperature and time for the preparatory processes are maintained at 100^0C for 90 min. The fabrics are then thoroughly washed in cold water and dried in air. The dyeing processes adopted are same for both the fabrics, which are mentioned below. In both the cases quantity of mordanting salt and the dyes are kept identically same. These ready fabrics are now taken for dyeing and printing. The steps performed in the conventional dyeing and printing process and that with the special process are given below in brief.

Conventional method for dyeing and printing

The conventional process has been performed with a liquor ratio of 1:20 for cotton and 1:50 for silk to get suitable working conditions for each of the materials. Other conditions like dyeing time and temperature are kept same.

After preparatory process, material weight is taken 20gm for both cotton and silk. Other steps are as follows:
a) Dyeing of the materials with 20 gm of dye at 85^0C for 60 min.
b) Post mordanting of the fabric with 4gms of metallic salt at 60^0C-70^0C for 20 mins.
c) Soaping of the fabrics with 2g/l non-ionic detergent at 50^0C for 10 minutes, cold rinsed and dried in air.
d) Printing of the fabrics with gum thickener containing pre-lake formed with dye and metal salt and subsequent drying in air.
e) Steaming of the dyed printed fabric at 102^0 - 110^0C for 30 min.
f) Aftertreatment with 2g/l non-ionic detergent at 50^0C for 5 min.
g) Cold rinsing and drying in air.

Special process of dyeing and printing

To save fuel for heating, the following processes have been performed. The main object is to use lakes prepared in advance in stead of forming lakes after dyeing or printing and, in short, the term 'pre-lake' is used in the special process

Pre-lake formation and padding process

The alternative new process has been performed by maintaining a material- liquor ratio of 1: 10 as the dyeing operation is done by padding method. At first pre-lake is formed with 20gm of dye and 4gm of metal salt at room temperature by mixing the dye and the salt with a little water in a separate container allowing a time of 15 min. Then it is diluted in the rest volume of water along with non-ionic wetting agent 1gm only for well anti-migration as well as dispersion action of the solution during padding. The next processes are as follows:
a) Padding of the fabric with dye liquor at room temperature at least for two times for evenness of the shade followed by drying in air.
b) Printing of the fabric with gum thickener containing pre-lake formed with dye and metal salt followed by drying in air.
c) Steaming of the dyed printed fabric at 102^0 - 110^0C for 30 min.
d) Aftertreatment with 2g/l non-ionic detergent at room temperature for 15 min.
e) Cold rinsing and drying in air

Padding Recipes

Cotton and silk fabrics are dyed by padding method using the pre-lake suspension containing dye and metal salt combined with an anti-migrating as well as dispersing agent in the following recipes. The lake formation is done with two different salts separately with one dye.

Recipe 1

For 200ml padding liquor: -
Lac / Terbula – 100gm/lt - 20gm
Ferrous sulphate – 20gm/lt - 4gm
Antimigrating agent – 5gm/lt - 1gm
Water – 200 ml

With the above recipe, both silk and cotton fabrics are dyed at room temperature by double padding method at 100% expression for getting evenness and deep penetration of the lakes.

Recipe 2

For 200ml padding liquor:
Lac / Terbula – 100gm/lt - 20gm
Aluminium sulphate – 20gm/lt - 4gm
Antimigrating agent – 5gm/lt – 1gm
Water –200 ml

With the above recipes, both cotton and silk fabrics are dyed at room temperature by double padding at 100% expression for getting evenness and deep penetration of the lakes.

The pad dyed fabrics intended for printing can be steamed after printing is completed. But for testing purpose, some portions of the fabrics are steamed and aftertreated as per previously described method. Rest fabrics are printed in pre-lake formation method.

Printing Recipe

The common recipe for printing is given below. The dyes and metal salts for printing are selected according to the dyed ground. Here Lac and Terbula have been used for printing according to depth, shade and tonal choice. After printing and drying, the fabric is dried in air and then steamed as per speculated time and temperature and rest aftertreatment is done. Advantage of this process is that the ground color and the prints are simultaneously fixed.
For 100 gm printing paste
Dye – 20gm
Metal salt – 4gm
Water – 16gm
5% gum thickener – 60gm

Testing of fastness of the dyed fabrics

Soap and Soda ash are strictly prohibited for Mordant class natural dyes as the shades are spoiled by their reaction. Hence non-ionic detergent is used in the washing fastness testing in very similar method of ISO2 with the help of Electrical Heating Continuous Stirring

Beaker Dyeing machine of EEC, Mumbai. Wet and dry rubbing fastness is taken with the help of Crockmeter in the standard method. The fastness results of the samples dyed with Lac and Terbula in both conventional exhaust process and pre-lake pad method for both cotton and silk are given in Table 1.

Table 1: Fastness results of the samples dyed with Lac and Terbula

Sample	Method	Washing Fastness		Rubbing	Fastness
		CC	CS	Wet	Dry
$Al_2(So_4)_3$ on cotton	Pad Exhaust	4-5 4-5	5 5	3-4 3-4	5 5
$Al_2(So_4)_3$ on silk	Pad Exhaust	4-5 4-5	5 5	3-4 3-4	5 5
Fe_3So_4 on cotton	Pad Exhaust	4 4	5 5	3 3	4-5 4-5
Fe_3So_4 on silk	Pad Exhaust	4 4	5 5	3 3	4-5 4-5

CC – Washing Fastness due to Change of Colour. CS - Washing Fastness due to Colour Staining

Mechanism of the pre-lake dyeing and printing process

It is known that lakes or chellates are formed due to reaction between mordant class natural dyes and metallic salts. Metal ions form ionic bonds with phenolic or carboxylic groups and co-ordinate bonds with co-valently bound anthraquinone groups of dyes. When a dispersion of such lakes are applied on cotton or silk fabric by padding method of printing through a printing paste, most of the colour lakes remain on the surface of the fabric, though a little quantity penetrates the fiber due to mechanical pressure. But when the dyed or printed fabric is steamed at 102^0-110^0C, the lakes are ionized again and enter the micro-holes of fiber due to ionic attraction between dye and fiber. As such, the metal ions have no affinity for cotton fiber, but they have attraction for the dye ions already deep seated in the fiber and again they form lakes due to ionic attraction. As the sizes of the lakes are bigger than the fiber micro holes, the lakes are entrapped inside fiber.

In case of silk, dye anions and metal cations have strong attraction towards positively charged amine and negatively charged carboxyl groups respectively. Hence they enter the fiber and form ionic bonding between dye and fiber, metal and fiber and finally with dye and metal ions. The dye- metal lakes thus produced also form co-ordinate bonds with the uncharged amine (-NH) groups of silk. Hence the depth of shade and fastness to washing for silk are both higher in comparison to cotton.

Result & Discussion

After performing both conventional and special innovative process applied on cotton and silk, the following observations are noted:

i. Fastness results of the dyed shades are almost equal in both the processes. In conventional process, scope of printing is limited, rather lengthy and very tuff. It is a common practice in the craft sectors that Fabrics are first treated either with metal salt or with dye and then printed with vice-verse to get the color designs. It also difficult to get a printed design on a complete white ground as some tinting effect comes after washing. But in this special process printed shades have come very clear. Moreover, printing can be done on any color ground or perfectly white ground.
ii. Conventional method is much time taking and therefore fuel consumption is higher than this special process. The shades achieved in the special process are also found darker and even in spite of using same dyes and salts. High depth printing is also possible in this process of pre-lake formation.
iii. Heating device is used for six times and total time is taken 215 min for conventional method.
iv. Heating device is used for two times and total time is taken 120 min for special method.

Conclusion

This innovative process for mordant class natural dyes has become successful by reducing carbon footprint due to less use of fuel. Therefore manufacturing cost will be reduced without hampering the fastness parameters. Moreover the time of production will be less than the conventional processes resulting higher production having impact upon product value. The 'Carbon foot print' problem being minimized, export market will have better scope in the innovative method. Though LPG gas does not directly produce carbon dioxide, but during burning it consumes sufficient oxygen indirectly increasing the carbon dioxide oxygen balance. To adopt this special process, craft sectors may use a suitable hand padding machine for the facility in production.

Reference

1. De Anil Kumar, *Environmental Chemistry*, 5th Edition, New Age International (P) Ltd., Publishers (2003).

Environmental compliance for textile dye effluent with special reference to vegetable dyes

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Abstract

All the "naturals" are not safe or environment friendly. The Natural/ vegetable dye effluent also need to be treated to comply with environmental statutory regulations by Pollution Control Board. Since the advantage with vegetable dye effluent is it's low BOD: COD ratio, the designing of effluent treatment process and effluent treatment plant (ETP) for vegetable dye effluent is much simpler compared to that for synthetic dyes. With simplified explanation of environmental statutory compliance parameters like BOD, COD, TSS, pH, temperature etc. and its effects, designing of ETP and prospect of environmental compliance have been made more users friendly in this paper.

***Keywords*:** Activated carbon, Activated sludge, Aeration, Adsorption, BOD, Clarifier, COD, Filtration, Natural dyes, Wood charcoal.

Reference

1. N. Manivasakam : Industrial Effluents – Origin Characteristic, effects analysis & Treatment . 1997
2. P.M.Chan , C.W.M. Yuen and K.W.Yeung : The effect of Natural Dye Effluent on Environment. RJTA , Vol 6, No 1
3. Natural Dyes – O ECOTEXTILES
4. Dr. Subrata Das : Textile Effluent Treatment – A case Study in Home Textile Zone.
5. Jaya Paul A /L Arumai Dhas : Removal of COD and Color from Textile Wastewater using Limestone and Activated Carbon , Dec 2008
6. Central Pollution Control Board (CPCB): Advance Methods For Treatment of Textile Industry Effluent, April 2007
7. West Bengal Pollution Control Board (WBPCB) : Norms

'Bagru' ——— A traditional printing technique of Rajasthan

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Abstract

Bagru printing is one of the traditional techniques of printing with natural colour followed by the *chippas* of a remote place of Rajasthan. The process starts from preparing the cloth to finished printed fabrics through their indigenous methods. Motifs having some specialty are transferred onto light coloured background with wooden blocks following two styles – direct and resist style. Although this technique is facing problems against the threat of globalization, this exotic art of creation is required to be encouraged in the present context of environmental consciousness.

Keywords: *Bagru* print, *Chippa*, *Dabu*, *Potai*.

Introduction

Indians were among the pioneers in the art of dyeing and printing with fast (natural) colour in the world. Dyeing with indigo was more of a mystery to many foreign travelers to India because they could observe no colour when fabric is dipped in indigo bath – colours develop during exposure in open air[1]. Hand block printing has been recognized as a craft through generations in different clusters in the country. Each cluster follows its distinctive style & methods, uses locally available natural materials and motifs of some specialty. 'Bagru' print is that kind of centuries old traditional art of hand block printing still alive.

In the interior of desert state of Rajasthan, at a distance of 30-35 kms from Jaipur, on Jaipur – Ajmer road there lies a small typical village called 'Bagru' having a population[2] of around 22,089 with male 52% and female 48%. The village town is not popular for any palace or fort but for keeping alive the three-centuries-old tradition of printing with the splendid efforts of artisans. It is unique for its indigenous style of printing using natural colours with wooden blocks known as 'Bagru printing'.

History

There is no authentic record for reference on backdating Bagru's block printing practices and there prevail different opinions behind its starting. However, it is estimated that this art form was introduced 450 years back when a community of *Chhipas* (literally meaning people who stamp or print) came to Bagru from *Sawai Madhopur (Alwar*), and settled in Bagru. Even today, their community works together in a place called Chhippa Mohalla (Printer's Quarters) by the *Sanjaria* riverside. It is perhaps the river name that lends it name to *Sanganeri* printing art form. The Chippas community settled along the riverside, like any other nomadic settlement. The bank of the river provided them with clay which is an important ingredient in getting the base color of the famed 'Bagru' prints. The artisans smear the cloth with Fuller's earth got from the riverside and then dip it in turmeric water to get the beige colored background. After that, they stamp the cloth with beautiful designs using natural dyes of earthly shades.

According to the opinion of other group, the tale unfolds more than 400 years ago when the Thakur on the lease of the village decided to develop Bagru as a centre for block printing and brought two families of printers from Isarda[3], a village near Jaipur. The printers locally known as *'Chippa'* came from the loyal patronage. The presence of abundant water in the overflowing '*Sanjaria*' river and its clean sunny river bed led to the settlement of the Chippas. Today though the river runs dry these artisans thrive in Bagru practicing their same methods of the past thus ensuring survival of the traditional art.

Process of Bagru printing

The process of Bagru printing is very simple as it looks the practice of printing and working with natural elements comprises a complex series of steps that includes:

(a) Preparing the raw cloth.
(b) Making dyes and colours.
(c) Steps involving different types of printing.
(d) Developing intricate dyeing technique for resist printing in particular.

The process starts with the plain cloth. The raw fabric usually containing different impurities like starch, oil and dust, which needs to be cleaned to remove those impurities initially for even and good penetration of colour. Chippas require two days to prepare a paste by mixing cow-dung, soda ash and sesame oil and washes the cloth with this mixture. This step is called scouring or locally as '*Hari sarana'*.

This cloth is then washed, dried and made ready for *'Harda'* treatment. *Harda* is a fruit that is considered to be the most important element of printing and dyeing technique of Bagru. This fruit along with its seed is powdered and mixed with water. Scoured fabrics are given thorough wash in this mixture giving a yellow tint to the cloth. This produces the light ground colour which differentiates 'Bagru' from 'Sanganer', always on white ground. Harda has natural Tanic acid in it that produces black prints with iron as mordant for Bagru black. The treated fabrics are then squeezed to dry and laid down in the sun. Abundance in water and sun shine are the most essential requirement for this process. Almost every stage requires the cloth to be washed with water and dried in sunlight. Now-a-days the used water is treated for recycling or charged into underground.

Two main types of printing are used commonly in Bagru[4]: direct dye printing and resisting printing. In both procedures, first the blocks are soaked overnight in mustard oil or refined oil and then washed. Printing is done on wooden table, the size of which depends on the length of to be printed (18 foot approx.). These tables have a layer of ply on which there are 20 layers of tart and a sheet of cloth on which comes the final fabric.

Direct Dye Printing

In the first process, the dye solutions are poured in the tray. The printer presses the block into the dye tray and then onto the cloth until the pattern is complete. For every imprint the block is pressed into the tray to get a fresh smear of paste. The outline pattern is done in blocks for the background and highlights in different colors. Once each pattern is complete, the cloth is ready for the dye vat. This printing is primarily done by male printers.

Resist Printing

Bagru is known for its mastery in the second type, a special printing technique of Resist style called '*Dabu*' printing. Its essence lies in printing with specially prepared *Dabu* paste i.e. applying thick black mud paste onto the fabric and then dyeing the fabrics. The prepared cloth is printed with *Dabu* paste by wooden blocks. Thereafter the printed cloth is dyed with natural colour, these results in resisting dyeing in the portions which were hidden and a printed effect is created in the fabrics. Each family follows its own secret of making *Dabu* paste. Although, women have traditionally done the dabu printing, men are also involving themselves in it.

Dabu preparation

In general Dabu is made by mixing:

(a) Lime dissolved in water,
(b) Natural gum '*Bedhan*' or the wheat flour spoiled by worms, and
(c) Locally available black clay

All these are mashed well into a thick paste and left overnight. It is then strained into liquid paste which is used for printing. The cloth is stretched on the table and blocks are selected to print designs on the cloth.

There are 3 types of Dabu depending on the final result and the colour required:

(a) *Kaligar Dabu* that is processed only once
(b) *Dolidar Dabu* that has little more of gum thus better adhesive strength and can withstand about two trips to the dye vats
(c) *Gawarbali Dabu* has oil and gawar seed powder added to the paste which gives strength to cloth to go through repeated dyeing.

As Dabu printing is completed, saw dust is sprinkled over the cloth before the prints dries completely to avoid sticking with each other.

Preparation of Dye solution

Dyeing process varies depending on the colour required. Bagru is known for its green shade that is acquired through two traditional methods:

In the first method, the cloth is sent to the indigo vats, dipped, taken out and dried in the sun. It is then rinsed in a pre-boiled and cooled solution of pomegranate peel and water that is prepared a day before. It is washed again and then rinsed in a solution of alum and water to fix the colour and also for removing *dabu* paste. As the cloth dries the *Bagru* print appears.

The other method is known as '*Potai'*. In this process, a paste is made of pomegranate peel, turmeric and sesame oil. The dabu printed fabric is hold tightly by four persons and with a piece of woven cloth the artisan generously applies the paste on the cloth. The fabric is then dried, dipped in a solution of alum and water. Alum is dissolved in water to acquire a clean solution. This solution is then strained through a cloth filter. Quantity of alum varies according to the strength of the dabu. A fabric not treated with alum solution produces prints blurred and shabby.

Bagru print is also famous for the use of two major colours – a red colour outline called '*Began'* and a black colour called '*Syahi'*. For making the red outline, alum, *Geru* and natural gum are mixed together with water to make a paste. As a type of foam forms, ghee and oil is added to it. This is called red *Began* colour and it is an important part of Bagru printing. Black *Syahi* is essentially a fermented solution of iron, molasses, gum and the starch of tamarind flour. This paste when applied on harda treated fabric turns black on getting exposure to the air.

Common vegetable colours used for Bagru printing

- Red or *Madder* from *Aahl* tree.
- Black from fermented Harda seeds.
- Blue from Indigo plant.
- Yellow from dried pomegranate rinds, turmeric and dried flowers of *Dhabaria* trees.

Preparation of Indigo colour

Indigo is a challenging dye to use since it is insoluble in water. For making it soluble it undergoes a chemical change. Natural indigo is boiled in *Pawar* seeds and kept overnight. The next day, this solution along with lime is dissolved in the vats that are 15 feet deep and left untouched for a day. Dyeing starts only after that. More dipping in the water brings a deeper blue colour and one can dip a fabric for maximum of 6 times. The fabric is then dipped in alum and water solution for fixing the colour.

Conclusions

Today, artisans of various regions are using modern techniques to develop their craft. While traditional art form is replaced by modern tools, techniques and synthetic dyes, many *Chhippas* have given up the art of hand block printing. Yet there are a handful of artisans who engross themselves in their traditional and distinct art of dyeing and printing. As the world is waking up to environmental consciousness and eco-friendliness, this captivating and exotic art is getting recognized day by day.

Reference:

1. Hipparagi S A, Sinha R K, Somashekar T H & Radhalakshmi Y C, Traditional Textiles printing in India, *Indian Silk, March 2007*, pp 4.
2. Census of India 2001, *Census Commission of India*.
3. Ramesha M N, Bagru- Enchanting prints from the Desert, *Indian Silk, March 200,* pp 36.
4. Mahajan S, Contemporisation of Bagru printing, www.fibre2 fashion.com

Different types of motifs used in *Bagru* printing:

The significant motifs of Bagru prints are:

(i) Aath Kaliyan *(ii) Bankadi*
(iii) Bada Bunta *(iv)Hajura*
(v) Bewada *(vi)Hara Dhania*
(vii) Kamal *(viii) Chopad*
(ix) Kel *(x) Pyala*
(xi) Chhota Bel

New age marketing concept of Indian textile products

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Abstract

Textile becomes key value driver for Indian GDP growth and it is one of the major contributors of India's export earnings. Export is essential for Indian economy to reduce the trade deficit (difference of earnings in import and export) despite of India's growing domestic. Some of the key commodities like petroleum products are required to be imported and those are now become major reason for negative cash flow in Import account. Textile is not a high value items so despite of huge quantity export, the contribution in monitory terms are not so great. Needless to mention that Indian Spinners have to place themselves as a leader in value added textiles and other textile products which are at the upper tier in the value chain. It doesn't mean that we would ignore or remove the attention for supplying traditional/already established textile items in overseas. In this paper, the author has highlighted one of the most contemporary approaches ——— **relationship marketing** to accomplish this goal, which is a combination of many complementary and supplementary marketing functions, organization's structure, ethos and philosophy of the management towards the business. Relationship marketing is the total marketing where customer is in focus, contrary to the early age business philosophy where product and production was considered as focal area. Most significantly, in relationship marketing, the all support functions have to be synchronised to deliver uninterrupted and smooth output to deliver the best possible customer satisfaction. Customer orientation, retention and satisfaction are the key result driver for relationship marketing. Where as, to design effective result oriented full proof system, there is no substitute for being leaders in all of the 7p's (product, price, place, promotion, physical distribution, positioning and people) in the contemporary marketing functions. In relationship marketing, long term strategy is a key thing for the survival and sustainability of the organisation so the key leaders in the marketing team have to have the ability to do the internal marketing. Internal marketing is the concept of supplier/customer relationship in all supportive functions in the organisation so in a sense everyone in the organisation is the part of marketing team and having one goal to achieve ultimate customer satisfaction. According to the author, the best thing in relationship marketing is Customer Retention, so the late implementers of this concept would have to try more to get the new customer from their competitor's fold.

***Keywords*:** Contemporary approaches, Customer retention, Export, GDP, Import, Relationship marketing, 7p's.

Introduction

The textiles industry in India enjoys a distinctive position due to the pivotal role it plays by way of contribution to industrial output, employment generation (second largest after agriculture) and export earnings of the country. The industry is rich and varied, embracing the hand-spun and hand-woven sector at one end and the capital intensive, sophisticated mill sector at the other. Its association with the ancient culture and tradition of the country lends it a unique advantage in comparison with textiles industry of other countries, thus giving it an uncommon edge to cater to a vast variety of products and market segments both domestically, as well as, globally.

The industry currently contributes about 14 per cent to industrial production, 4 per cent to GDP, and 17 per cent to the country's export earnings, according to the Annual Report 2010-11 of the Ministry of Textiles. The industry accounts for nearly 12 per cent share of the country's total exports basket. It provides direct employment to more than 35 million people.

Industry sub-sectors

The textile industry comprises the following:

- Organized Cotton/Man-Made Fibre Textiles Mill Industry
- Man-Made Fibre / Filament Yarn Industry
- Wool and Woollen Textiles Industry
- Sericulture and Silk Textiles Industry
- Handlooms, Handicrafts, the Jute and Jute Textiles Industry
- Textiles Exports

Market size

The Vision Statement for the textiles industry for the 11th Five Year Plan (2007-12) sees India securing a 7 per cent share in the global textiles trade by 2012. At current prices, the Indian textiles industry is valued at US$ 55 billion, 64 per cent of which caters to domestic demand.

The export of textiles and clothing (T&C) aggregated to US$ 22.42 billion in 2009-10. The Government fixed the target for 2010-11 at US$ 25.48 billion. So far during the period April- September 2010, exports of T&C have been achieved at US$ 11.26 billion.

Production

During February 2011, total cloth production rose by 5.8 per cent year-on-year (y-o-y). During April- February 2011 cloth production increased by 4.5 per cent y-o-y.

Export

Total textile exports during April-December 2010 registered an increase of 16.54 per cent in rupee terms at Rs 87,582.83 crore as against Rs 75,149.98 crore during the corresponding period of the previous year, according to the latest data released by DGCI&S, Kolkata. The same were valued at US$ 19,217.12 million as against US$ 15,695.07 million during the corresponding period of the previous year, registering an increase of 22.44 per cent.

The share of textile exports in total exports was 11.29 per cent during April-December 2010 as against 12.34 per cent during April- December 2009.

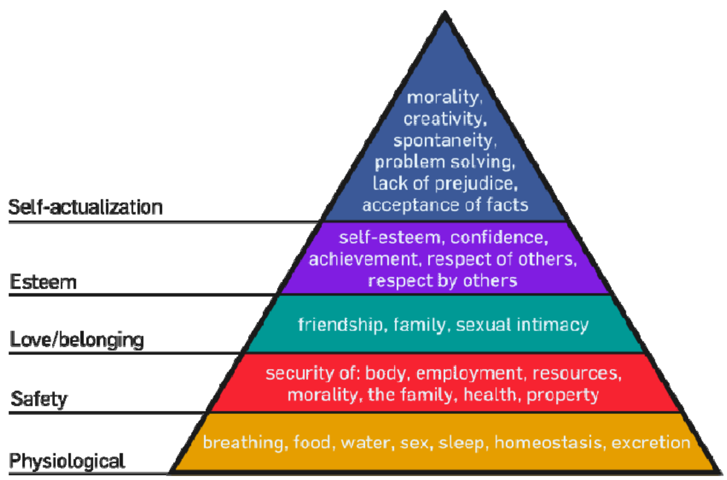
So in a nutshell Textiles is an important activity for India's growth point of view.

Growth is measured in terms of money especially in market economy where the whole globe is a market for everyone and every one wants to be the leader in various segments of products and services.

If we go see the Maslow's need hierarchy model, the Textile is coming under Physiological need and that would be the need of every human being of the globe. In extremely diverse society of Globe there are multi segments of textile products and despite of catering huge domestic need, for India it is essential to reach all possible segments of textiles of overseas market.

So, till now what Indian exporters are doing largely?

Textile is age old Industry of all oldest civilization like India, China, Middle east, Latin America etc. But in true sense, Textiles products started being market Globally when Industrial revolution had occurred in between 18th to 19th century in Europe and by the power of colonial rule mostly British traders and businessman was the first who started dumping power loom fabrics in Indian market. Before Muslim rule Indians didn't know to wear stitched fabric and the cloth / fabric used to manufacture in hand spinning (*Charkha*) and hand loom (*Tant*) by Weavers' community. To spread the machine manufactured cloth British had destroyed the local manufacturing base forcefully and diplomatically and monopoly situation had been created.



Just after two decades of Independence of India, European's has started struggling to achieve low cost manufacturing Textiles – mainly apparels.

In this context, I should mention about the value chain of the textiles. Modern textiles have value stages like fibres – yarns – fabric (woven / knitted) – garment and for knitwear segment fibres – yarns – knitted garment. Ideally the maximum profitability or value creation can be achieved in dealing the products which are in the highest level of value chain.

So, it is quite evident that selling of yarn would be much profitable than selling of fibre; similarly selling of fabric would create more value than that of yarn and needless to mention garment selling should give much return than selling of fibre, Yarn and fabric.

Now, question comes if profit maximization can be achieved by selling the product in highest value chain i.e. garment then why all are not concentrating on selling such thing.

Before answering this question let me mention the total segment of garment textiles where small unorganised tailors to big quantity selling retails, high end organised brand both local and global, high end and medium end boutique, big unorganised basic garment sellers – everyone is there. Profit margin varies in different segments and with the economies of scale.

Suppose one up market retail is selling one garment with profit margin 20% whereas the same product is available in mass market retail with lower price so certainly mass market retailers are not getting same % of profit but due to maximising qty. they could able to generate more value from the same business.

Let me back to the general marketing concept of Textile marketing – Traditional method and contemporary style.

Textile product marketing can be broadly divided into two parts –

B2B and B2C

B2B is – fibre, yarn, fabric and even garment marketing / selling which is also termed as Industrial selling.

Fibre manufacturer will sell their product to Spinner.

Then Spinner will sell the yarn (manufactured from the fibre) to the fabric manufacturer or knitter.

Knitter will then send to garment manufacturer and garment will move from them to Retailer.

So in B to B chain all people are buying textiles for business means adding some value before it moves to next value chain.

B2C

When you or I are buying some product form the market then the transaction / business is called B to C.

In textile business garment or final products like carpet, throws, home furnishing fabrics, hand knitting yarns are direct consumer items where one or more business house are selling / targeting individual customer.

Traditional method of Textile marketing

- Economy of scale: Maximizing the capacity to achieve lowest possible per unit cost.
- Try to achieve monopoly: Focus only on finishing the competition by all possible way.
- Standardisation in manufacturing to achieve cost effective product: To avoid the changes in manufacturing as minimum as possible and manufacturing same product day in day out to maximize efficiency to bring down the cost of production.

- Using various channels of marketing like retailers / dealers / exclusive outlets or shops: Selling strategy by developing external marketing channel like agents, dealers, exclusive retailers to reduce the fixed marketing cost and minimize the cost of customer development.
- Marketing personnel are concentrating on transaction rather than developing relationship with customers: Follow the strategy more transaction and more sales so efficient transaction experts considered as best marketing personnel who can only creates the sales volume in short term and maximum mid term basis to run the show.
- Reactive approach to launch a new product: When customer ask to develop something then work on the new product to get the immediate gain from R&D.
- After sales services – Through channels not by direct company representative to save cost.
- Customer grievance – Try to sort out customer complaint keeping in mind company's own interest and avoid any direct financial compensation as max as

Contemporary Method

- Set the manufacturing capacity in the basis of market research report: Optimize the capacity in the basis of demand pattern and has ability to fine tune the manufacturing set up as per change in need by the customer or market.
- Strategise to become a leader in the competitive market for a particular product by developing USP of it.
- Flexibility in manufacturing set up as per customer need. Extra cost for producing non standard item can be recovered from the market in mid term or in short term.
- Develop marketing to reach the customer as close as possible. Develop a team who have the ability to listen the customer's need, anticipate and identify the potential need and communicate and covert that to their operation team to carry out or implement in the product.
- Develop marketing by relationship – if required channels to be there but customer access will be with the company always.
- The key thing in relationship marketing is close to customer – to make them feel that we are their partner not just seller.
- Develop the concept of strategic partnership of vendor-buyer to make the business more meaningful in terms of value creation.

- True implementation of customer servicing – on time in full (OTIF), proactive customer feed back system and design remedy short term as well as long term.
- Frequent one to one meeting with customer by company representative and try to add value keeping customer need in focus.
- Time to time send updated information to customer which are related to their business and your potential support if they would decide to implement any new strategy.
- Focus on NPD (new product development) to fulfil potential need of the customer. It is also a proven tool of demand creation.
- New model of after sales service is the key to the present days marking concept. In earlier approach customer has to run after the vendor to get the after sales services now it has become a package during selling of any product – in B2C it is quite evident like annual maintenance contract, 24x7 toll free help line etc. In B2B set up face to face approach and on time and on the spot support is required – otherwise next customer retention is virtually impossible. In fact customer retention index is the yard stick of the efficiency of a company's after sales services.
- Grievance handling is so important now-a-days, vendor is used to accept any complaint from customer in first even before judging whether it is right or wrong. An European retailer was introduced a system for refunding full money upfront if any of their customer has come and shows slightest discomfort after purchasing products form any of their outlets. A study has been done on their innovative and highly customer oriented move and it was found that 99% of the complaint were genuine in nature and their sale has gone up by 25% in next three months after introducing this system.

Back to Basics

In theory it looks very easy to implement a strategy and to derive a dream path for success but actually who are on the ground to implement it for accomplishment can understand the hard reality for change management. Experts say, before moving for change management it is necessary to focus on basics – here I mean to say back to basics.

We all know the basics of marketing but to draw quick co relation let me summarise the core marketing concept

What is marketing?

- Marketing is a process related to product and services keeping focus on customer.
- It determines what products or services may be of interest to customers.
- The strategy to use in sales, communications and business development.
- It generates the strategy that underlies sales techniques, business communication, and business developments.
- it is an integrated process through which companies build strong customer relationships and create value for their customers and for themselves.

What marketing is doing?

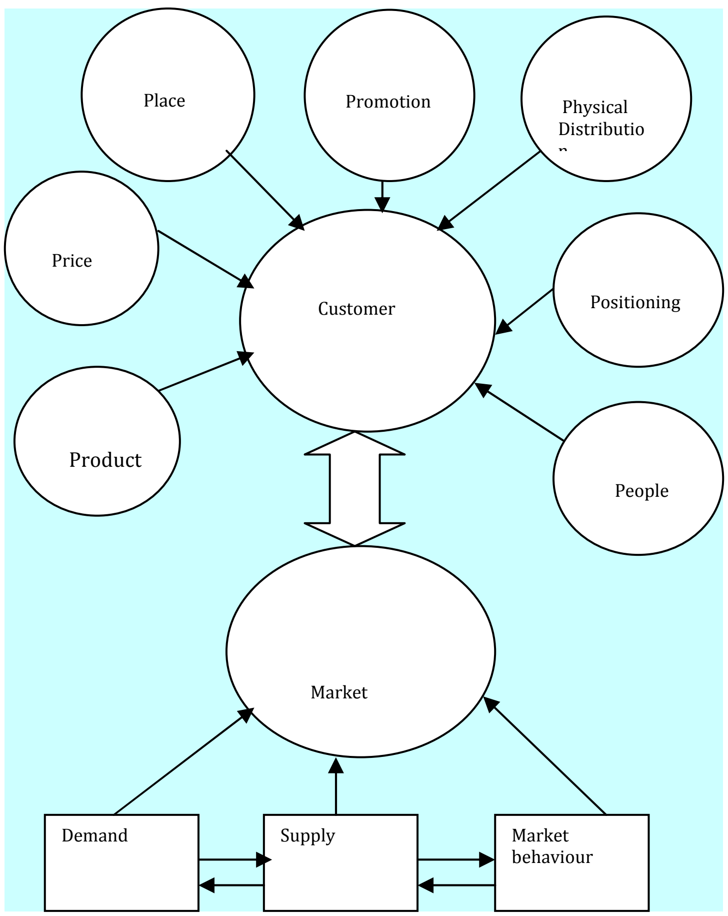
- Marketing is used to identify the customer,
- satisfy the customer,
- Retain the customer.

How it (marketing) works?

- Marketing strategies requires businesses to shift their focus from production to the perceived needs and wants of their customers as the means of staying profitable.
- Knowing the needs and wants of target markets and delivering the desired satisfactions to the customer.
- In order to satisfy its organizational objectives, an organization should anticipate the needs and wants of consumers and satisfy these more effectively than competitors.

Marketing process

Marketing process is an encyclopaedia. In simplest and most generalised way to explain it as a combination of 7P's with demand, supply and market behaviour. Sellers have to manage the 6p's most effectively and their aim should be to place themselves in the top with respect to 7p's among competitor's net rating in 7p's.



Depending of the **product** and market behaviour, emphasis of different P's are used to vary. Like the product which is pick of its life cycle then price may not get the highest weightage in terms of sells volume but in the fag end of its life cycle, product has to compete in terms of price. All commodity goods are used to enjoy very short pick so most of their life cycle they have to be price competitive. Like basic cotton yarn, jute bags, ecru twill fabrics, mass market garments are the commodities in textiles.

Price is a peculiar thing – very few marketing expert can able to accurately pricing their product. Although cost is the major contributory factor for determining the price but price strategy is entirely independent to the cost of the product. In general, price is market driven and market is again dynamic domain which expands or contracts by the influence of demand and supply. And demand, supply and market behaviour are interlinked with each other.

Place – To select place where to sell the product. For monopoly situation, seller has enough choices to decide the place it is sell but competitive situation where there is no room for the seller to move as per their own choices.

Promotion– Advertisement and promotion is a key tool to reach the customer, to educate and lure them to go for that. It is playing with present need, potential need and hidden need of the customer and repeat and regular promotional activity are helping the product to stay in the market for long. In large selling consumable item this activity is leading towards Brand building exercise especially for B2C marketing. Promotion or advertisement is required by the B2B selling but their media is different than that of B2B.

Physical Distribution should be managed highest level of efficiency to achieve on time full delivery as per commitment.

Positioning – Same quality (basic ingredients are similar) garment can be sold in 200 buck as well 5000 buck depending how would it be positioning in the market as well as in front of the customer.

People – This concept is coming in new age marketing in India. Retail boom is yet to be started in India and most of the retail players are now focussing on their front line sales team as well as back office people's attitude towards the customer. You may agree with me that people are used to go same shop year after year just because of their salesmen are capable to create feel good factor. They may be lacking in other P's with their competitors but people can able to drive the things in positive direction.

Starting point of new-age marketing lies with this P.

We have to go back the history of marketing once again.

Earlier approaches of Marketing Concept

Orientation	Profit driver	Western European timeframe	Indian Time Frame	Description
Production	Production methods	until the 1950s	Till late 70's	Economy of scale, high technology to enhance productivity and the whole management focus is on product and production to maximize the profit.
Product	Quality of the product	until the 1960s	Till late 80's	A firm employing a product orientation is chiefly concerned with the quality of its own product. A firm would also assume that as long as its product was of a high standard, people would buy and consume the product.
Selling	Selling methods	1950s and 1960s	After opening up Indian economy, Indian manufactures got freedom to do business on their own without much intervention by the Govt.	A firm using a sales orientation focuses primarily on the selling/promotion of a particular product, and not determining new consumer desires as such. Consequently, this entails simply selling an already existing product, and using promotion techniques to attain the highest sales possible. Such an orientation may suit scenarios in which a firm holds dead stock, or otherwise sells a product that is in high demand, with little likelihood of changes in consumer tastes that would diminish demand.
Marketing	Needs and wants of customers	1970 to present day	21st Century businessman has started focusing on marketing driven organization.	It involves a firm essentially basing its marketing plans around the marketing concept, and thus supplying products to suit new consumer tastes. As an example, a firm would employ market research to gauge consumer desires, use R&D to develop a product attuned to the revealed information, and then utilize promotion techniques to ensure persons know the product exists.

Contemporary approaches

Recent approaches in marketing include relationship marketing with focus on the customer, business marketing or industrial marketing with focus on an organization or institution and social marketing with focus on benefits to society. New forms of marketing also use the internet and are therefore called internet marketing or more generally e-marketing, online marketing, search engine marketing, desktop advertising or affiliate marketing. It attempts to perfect the segmentation strategy used in traditional marketing. It targets its audience more precisely, and is sometimes called personalized marketing or one-to-one marketing. Internet marketing is sometimes considered to be broad in scope, because it not only refers to marketing on the Internet, but also includes marketing done via e-mail and wireless media.

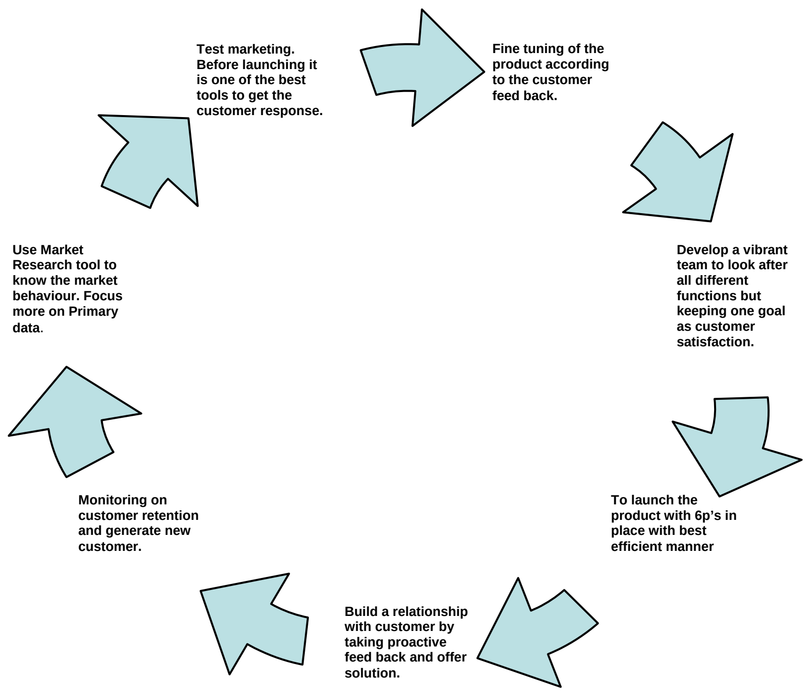
Orientation	Profit driver	Western European timeframe	Indian Time Frame	Description
Relationship marketing / Relationship management	Building and keeping good customer relations	1960s to present day	Late 90's	Emphasis is placed on the whole relationship between suppliers and customers. The aim is to provide the best possible customer service and build customer loyalty.
Business marketing / Industrial marketing	Building and keeping relationships between organizations	1980s to present day	After 21st century (2000-2002), Indian businessman has to adopt this.	In this context, marketing takes place between businesses or organizations. The product focus lies on industrial goods or capital goods rather than consumer products or end products. Different forms of marketing activities, such as promotion, advertising and communication to the customer are used.
Social marketing	Benefit to society	1990s to present day	It is started putting foot hold in India almost a decade ago and gradually growing.	Similar characteristics as marketing orientation but with the added proviso that there will be a curtailment of any harmful activities to society, in either product, production, or selling methods.
Branding	Brand value	1980s to present day	Late 90's after significant growth of Indian middle class and more and more people has started earning disposable income.	In this context, "branding" is the main company philosophy and marketing is considered an instrument of branding philosophy.

Key Result Driver for relationship marketing

Customer orientation

A firm in the market economy survives by producing goods that persons are willing and able to buy. Consequently, ascertaining consumer demand is vital for a firm's future viability and even existence as a going concern. Many companies today have a customer focus (or market orientation). This implies that the company focuses its activities and products on consumer demands. Generally, there are three ways of doing this: the customer-driven approach, the market change identification approach and the product innovation approach.

In the consumer-driven approach, consumer wants are the drivers of all strategic marketing decisions. No strategy is pursued until it passes the test of consumer research. Every aspect of a market offering, including the nature of the product itself, is driven by the needs of potential consumers. The starting point is always the consumer. The rationale for this approach is that there is no reason to spend R&D funds developing products that people will not buy. History attests to many products that were commercial failures in spite of being technological breakthroughs.

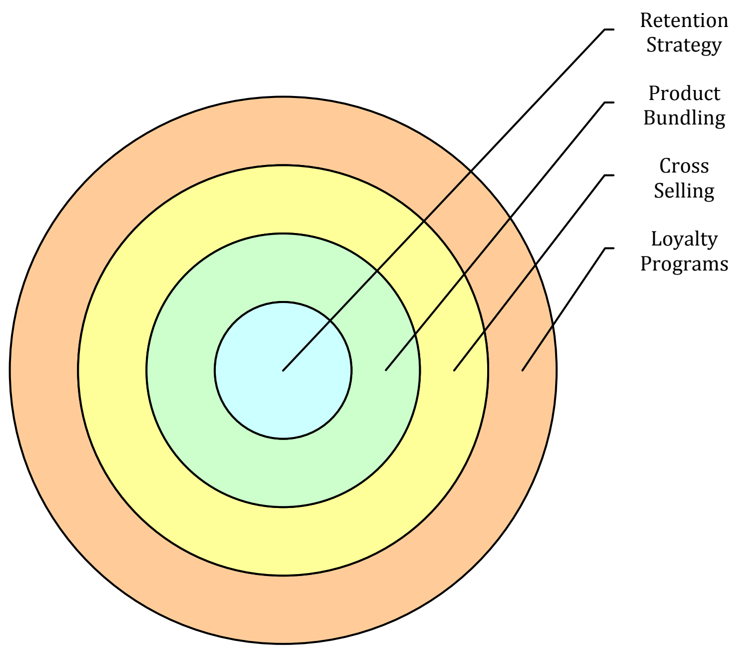


Customer retention and satisfaction

With the growth of the internet and mobile platforms, relationship marketing has continued to evolve and move forward as technology opens more collaborative and social communication channels. Relationship marketing extends to include inbound marketing efforts, (a combination of search optimization and strategic content), PR, social media and application development. Relationship marketing is a broadly recognized, widely-implemented strategy for managing and nurturing a company's interactions with clients and sales prospects. It also involves using technology to organize, synchronize business processes, (principally sales and marketing activities), and most importantly, automate those marketing and communication activities on concrete marketing sequences that could run in autopilot, (also known as marketing sequences). The overall goals are to find, attract and win new clients, nurture and retain those the company already has, entice former clients back into the fold, and reduce the costs of marketing and client service. Once simply a label for a category of software tools, today, it generally denotes a company-wide business strategy embracing all client-facing departments and even beyond. When an implementation is effective, people, processes, and technology work in synergy to increase profitability, and reduce operational costs.

Satisfaction

Relationship marketing relies upon the communication and acquisition of consumer requirements solely from existing customers in a mutually beneficial exchange usually involving permission for contact by the customer through an "opt-in" system. With particular relevance to customer satisfaction the relative price and quality of goods and services produced or sold through a company alongside customer service generally determine the amount of sales relative to that of competing companies. Although groups targeted through relationship marketing may be large, accuracy of communication and overall relevancy to the customer remains higher than that of direct marketing, but has less potential for generating new leads than direct marketing and is limited to Viral marketing for the acquisition of further customers.



Retention

A key principle of relationship marketing is the retention of customers through varying means and practices to ensure repeated trade from preexisting customers by satisfying requirements above those of competing companies through a mutually beneficial relationship.

Advantage of customer retention –

- Study shows (Reichheld and Sasser) that 5% improvement in customer retention can cause increase in profitability by 25% to 85% depending on the nature of Industry.

- Customer Account Maintenance costs declined as a percentage of total costs.
- Long tern customers tend to be less inclined to switch and also to be lesser price sensitive.
- Long-term customers are more likely to purchase ancillary products and high margin supplemental products.
- Customers that stay with you tend to be satisfied with the relationship and are less likely to switch to competitors, making it difficult for competitors to enter the market or gain market share.
- Regular customers tend to be less expensive to service because they are familiar with the process, require less "education", and are consistent in their order placement. Increased customer retention and loyalty makes the employees' jobs easier and more satisfying. In turn, happy employees feed back into better customer satisfaction in a virtuous circle.

Retention strategies also build barriers to customer switching. This can be done by

- ✓ product bundling (combining several products or services into one "package" and offering them at a single price)
- ✓ Cross selling (selling related products to current customers)
- ✓ Cross promotions (giving discounts or other promotional incentives to purchasers of related products)
- ✓ Loyalty programs (giving incentives for frequent purchases)

Many relationship marketers use a team-based approach. The rationale is that the more points of contact between the organization and customer, the stronger will be the bond, and the more secure the relationship.

The six markets model

Christopher, Payne and Ballantyne (1991) from Cranfield University goes further. They identify six markets which they claim are central to relationship marketing. They are: internal markets, supplier markets, recruitment markets, referral markets, influence markets, and customer markets. Referral marketing is developing and implementing a marketing plan to stimulate referrals. Although it may take months before you see the effect of referral marketing, this is often the most effective part of an overall marketing plan and the best use of resources.

Marketing to suppliers is aimed at

ensuring a long-term conflict-free relationship in which all parties understand each others' needs and exceed each others' expectations. Such a strategy can reduce costs and improve quality.

Influence markets involve a wide range of sub-markets including: government regulators, standards bodies, lobbyists, stockholders, bankers, venture capitalists, financial analysts, stockbrokers, consumer associations, environmental associations, and labor associations. These activities are typically carried out by the public relations department, but relationship marketers feel that marketing to all six markets is the responsibility of everyone in the organization. Each market may require its own explicit strategies and a separate marketing mix for each.

Conclusion

Relationship Marketing refers to a long-term arrangement where both the buyer and seller have an interest in providing a more satisfying exchange. This approach attempts to transcend the simple purchase-exchange process with a customer to make more meaningful and richer contact by providing a more holistic, personalized purchase, and uses the experience to create stronger ties. Relationship marketing has also been strongly influenced by reengineering. According to (process) reengineering theory, organizations should be structured according to complete tasks and processes rather than functions. That is, cross-functional teams should be responsible for a whole process, from beginning to end, rather than having the work go from one functional department to another. Traditional marketing is said to use the functional department approach. The legacy of this can still be seen in the traditional four P's of the marketing mix. Pricing, product management, promotion, and placement. According to Gordon (1999), the marketing mix approach is too limited to provide a usable framework for assessing and developing customer relationships in many industries and should be replaced by the relationship marketing alternative model where the focus is on customers, relationships and interaction over time, rather than markets and products. In contrast, relationship marketing is cross-functional marketing. It is organized around processes that involve all aspects of the organization. In fact, some commentators prefer to call relationship marketing "relationship management" in recognition of the fact that it involves much more than that which is normally included in marketing.

Relationship marketing involves the application of the marketing philosophy to all parts of the organization. Every employee is said to be a "part-time marketer". The way Regis McKenna (1991) puts it: "Marketing is not a function, it is a way of doing business . . . marketing has to be all pervasive, part of everyone's job description, from the receptionist to the board of directors. In other words involvement from management to lower down the order for customer satisfaction in true sense is the key to success. Especially the batch process like Textiles where technology is not like rocket science personal touch and perfection in output is essential. India is eying towards increasing the Textile export since this is one of the biggest way to reduce India's trade deficit. And to achieve this, the demands and expectations of overseas buyer must be fulfilled by any means. Some demands are explicit and some demands may be hidden or customer can put is across in subtle way. This sensitivity is must for the front line marketing person to understand the need and then success lies how well he/she could able to percolate the demand and need of the customer among his/her team members. In the team management will be there and the operator in the shop floor will also be there. The spreading of customer orientation would be different in different level of team members but effect and result should be same and unique.

This is a stiff challenge in front of Textile Industries in India considering preset mindset but I would say it is not impossible. Some of them have already started and also enjoying the success and hopefully rest will fall in same line.

Use of natural dyes for antimicrobial finish

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Abstract

The synthetic dyes and finishing chemicals are employed to the natural and synthetic fibre-fabrics for getting different functional properties, which are not that much eco-friendly and biodegradable in nature. The 'Green' technological concept has revolutionized the textile and fashion world by changing the idea of the new generation to use natural products and materials in their daily life style. In the horizon of Green Technology, natural antimicrobial dyes have played a vital role to dye natural fibres for developing natural antibacterial and colouring effects simultaneously. In the present work, few selected antimicrobial natural dyes were successfully applied (keeping dye concentration 20%) on mordanted cotton fabrics and a moderate to good washing and antimicrobial properties were obtained in the final products.

Keywords: Antimicrobial, Biodegradable, Eco-friendly, Natural products, Green Technology.

Introduction

The growth of micro-organisms on textile materials inflicts a range of negative effects not only on the textile itself but also on the wearer. These impacts include the generation of unpleasant smell, stains and discoloration in the fabric, a reduction in fabric strength and an increased likelihood of contamination. Microorganisms are found almost everywhere in the environment and can multiply quickly when basic requirements, such as moisture, nutrients and temperature are met. Mostly few synthetic fibers, due to their high hydrophobicity, are more resistant to microbial attack than natural fibers like cotton, silk and jute etc. The first antimicrobial textile finishes, used during World War II, was made to prevent cotton textiles, such as tents, tarpaulins and vehicle covers from rotting [1].There are several methods by which textile products can achieve antibacterial function. The simplest one is that an antimicrobial textile is chemically treated to kill, or suppress the growth of harmful microorganisms like- *Staphylococcus aurues or Pyogens, Staphylococcus epidermidis, Corynebacterium, Escherichia coli, Aspergillus niger, Aspergillus furnigatus etc.*

Most of the antimicrobial agents recently being used in the textile industry are from synthetic base and are not eco-friendly. Hence, recent research is emphasized on extracting antimicrobial agent from natural compounds. The use of natural products such as *Chitosan* [2-4] and some natural dyes [5,6] for antimicrobial finishing of textile materials has been widely reported. However, commercial applications are yet to be reported except *Chitosan*. There are several major challenges regarding extraction and isolation of the bioactive compounds, their application and durability. Nevertheless, due to their eco-friendly and non-toxic properties they are now suitable antimicrobial agents for textiles. However, in recent years, the use of natural dyes has assumed significant importance in application on textiles for replacing some hazardous synthetic dye due to their inherent properties and increased environmental awareness. *Punica granatum* L. and many other common natural dyes are reported as potent antimicrobial agents owing to the presence of a large amount of tannins [7]. Several other sources of plant dyes rich in naphthoquinones such as lawsone from *Lawsonia inermis* L. (henna), juglone from walnut and lapachol from alkanne are reported to exhibit antibacterial and antifungal activity [8]. Singh et al. [9] have studied the antimicrobial activity of some natural dyes. Optimized natural dye powders of *Acacia catechu* (L.f.) Willd, *Kerria lacca*, *Rubia cordifolia* L. and *Rumex maritimus* were obtained from commercial industries and they showed antimicrobial activities.

Keeping the above in view, a preliminary work was carried out by us to study the antimicrobial property of natural dyes collected from some plant resources available in the coastal district of Odisha and possibility of their application on textile materials.

Materials & Methodology

Different parts of the various dye-yielding plants were collected from the Nuapatna Handloom Cluster for extraction of dyes. The details of the plant sources are given below Table 1.

Table-1 Details of the samples sourced from various dye-yielding plants

English Name of the plant	Botanical Name of the plant from which sample taken	Type of samples sourced
Teak	Tictona grandis linn	Green leaves
Banana	Musa acuminate, Musa balbisiana	Dry leaves
Mango	Mangifera indica	Dry wood/ Green leaves
Marigold	Calendula officinalis, Tagetis	Flower
Acacia	Acacia auriculiformis	Skin
Chowlkodi (Kodiarsu)	NA	Dry stem
Ratanjoti	Jatropha curcus	Flower

Extraction of dyes

The natural dyes were extracted by boiling the above substrates in water without any chemicals. 100g of dry substrate was taken in a stainless steel container with 5litres of water and boiled vigorously for 4-5 hours with intermittent stirring. The dye liquor was then collected and kept apart. 50 ml of dye liquor was taken in a glass beaker and dried in a hot air oven till it was solidified. Then the dye was collected in powder form. The process was repeated for extraction of dye from all variety of samples.

Antimicrobial testing

AGAR Test was carried out by using following stains.

- Staphylococcus aureus(SA)

- Shigellaflexneri(SF)
- Bacillusubtilis(BS)
- Escherichia colli (E.colli)
- The results are given in Table-2

Dyeing process

Two methods have been adopted for dyeing the cotton fabric samples with different varieties of natural dyes i.e. pre-mordanting method and post mordanting method by following dyeing conditions.

Bleached cotton fabric-4gm; M : L = 1:10 ; Dye- 20% conc.
Dyeing & mordanting Temperature -100^{0}C
Dyeing & mordanting Time- 30min & 1.5 hours.
Copper sulphate: ferrous sulphate = 1:1

Antimicrobial test of dyed fabric

This test was done to know the extent of retention of antimicrobial property on the fabrics surface after dyeing. Because during dyeing two types of mordants (copper sulphate& ferrous sulphate) were used, which could affect differently in different types of microbes. The fabric was prepared as per the specimen required i.e. the fabric sample was in circular shape at 10 mm diameter. Nutrient agar media solution was prepared with mixing agar, peptone, sodium chloride, and beef extract. The media solution, swab were sterilized in aqueous media at 120°C in autoclave for 20 min. The petri plates were sterilized in dry medium in oven at 120°C for 15-20 min. Then the nutrient agar solution was applied over all the petriplates. Over which the dyed fabric samples cut in circular shape at 10mm diameter were laid and bacteria cells were inoculated on the nutrient agar plates. The plates were then incubated at 37-38°C for 24 hour. Then the microbial growth was evaluated by measuring the diameter of the zone of inhibition around the each fabric sample. The said process was followed for both pre-mordanting and post- mordanting dyed fabric samples before and after washing. The results are given in Table 3 & 4.

Colour fastness to washing

Colour fastness to washing of the dyed fabric samples was determined as per IS: 3361-1979. The wash fastness rating was assessed using grey scale.

Results and discussion

Natural dyes obtained from different plant species were tested for their anti-microbial activity against selected four microbes *(Escherichia coli, Bacillus subtilis, shigellaflexneri, staphylococcusaureus).* It is found that five natural dyes *Chawalkodi , Teak green leave , Mango dry wood powder, Marigold flower, Acasia skin* showed maximum zone of inhibition thereby indicating antimicrobial activity against all four bacteria *Staphylococcus Aureus, Shigellaflexneri, Bacillusubtilis, Escherichia coli* [Table-2]. Rathanjyoti was found to be resistant to two microbes Bacillusubtilis & Escherichia colli and Banana dry leave showed resistance to three microbes Shigellaflexneri, Bacillusubtilis and Escherichia colli. But both the dyes exhibit poor zone of inhibition as seen from Fig. 1. Since the dyes extracted from the above plant species showed good antimicrobial activity against selected microbes, it was thought worthwhile to study their antimicrobial activity on application of such dyes on textile materials. The cotton fabric samples dyed with each dye extraction were tested for their antimicrobial activity against same microbes. The results show that there is a reduction in size of inhibition zone after dyeing (both in pre-mordanting and post-mordanting method of dyeing) in comparison to that of dyeing solution [Table 3-4]. Further, a drastic reduction in size of inhibition zone is observed in case of all dyed samples after washing. It indicates less potency of antimicrobial activity of such dyes after application on textile materials. This might be due to poor uptake of dyes molecule in the fabric. The durability of the antibacterial activity of the dyes in the fabric samples seem to be unstable after washing, as the rating of colour fastness to washing is mostly in the range of 2-3 [Table -5].

Table 2: Zone of Inhibition for Natural Dyes Against Selected Microbes Tested at 20% Concentration of Dye

	Zone Of Inhibition for Natural Dyes Against Selected Microbes(diameter in mm)			
Different Dyes (20%)	Staphylococcus aureus (SA)	Shigellaflexneri (SF)	Bacillusubtilis (BS)	Escherichia colli (E. Coli)
Chawalkodi	21	26	25	24
Rathanjyoti	-	-	15	14
Teak green leave	17	18	16	18
Banana dry leave	-	15	16	12
Mango dry wood powder	22	22	24	19
Marigold flower	22	20	20	15
Acasia Skin	18	21	18	20

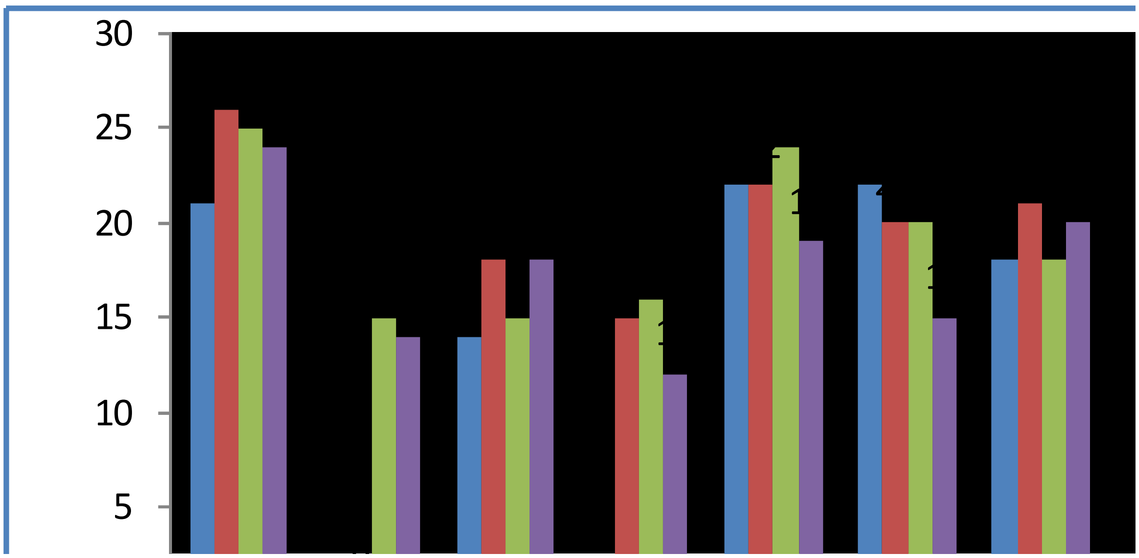

Fig. 1: (Y-axis -Zone of inhibition in mm and X-axis-Name of Natural dyes)

Table 3: AGAR test of dyed fabric (pre-mordanting) before and after washing fastness testing

Strains	Without washing Diameter of zone of inhibition in mm							After washing fastness testing Diameter of zone of inhibition in mm						
	CK	RJ	TGL	BDL	MDW	MF	AS	CK	RJ	TGL	BDL	MDW	MF	AS
SA	19	-	16	-	22	21	16	09	-	-	-	06	11	05
SF	22	-	18	16.	18	19	20	08	-	04	-	08	09	10
BS	22	15	16	12	22	20	18	07	-	06	-	05	10	08
E.Coli	21	12	17	14	18	18	19	05	-	-	-	04	08	05

CK-Chawalkodi , TGL-Teak green leave , MDW-Mango dry wood powder, MF-Marigold flower, AS-Acasia skin, RJ-Rathanjyoti, BDL-Banana dry leave.

Table 4: AGAR test of dyed fabric (post mordanting) before and after Washing

strains	Without washing Diameter of zone of inhibition in mm							After washing Diameter of zone of inhibition in mm						
	CK	RJ	TGL	BDL	MDW	MF	AS	CK	RJ	TGL	BDL	MDW	MF	AS
SA	21	-	18	-	23	22	21	09	-	07	-	10	11	08
SF	23	-	19	17	22	24	22	11	-	06	05	08	09	10
BS	24	15	21	14	22	21	21	10	05	04	-	05	10	07
E.Coli	24	14	22	18	21	22	20	11	-	10	-	06	09	08

CK-Chawalkodi, TGL-Teak green leave, MDW-Mango dry wood powder, MF-Marigold flower, AS-Acasia skin, RJ-Rathanjyoti, BDL-Banana dry leave.

Table 5: Washing fastness of dyed fabrics (pre-mordanting & post-mordanting)

Fabric dyed with	Washing Fastness					
	Change in shade		Stain on cotton		Stain on wool	
	Pre-mod.	Post-mod.	Pre-mod.	Post-mod.	Pre-mod.	Post-mod.
Banana dry leave	2	2/3	4	4	4	4
Mango dry wood powder	3	2/3	4	4/5	3	5
Chawalkodi	2/3	3	4/5	4/5	4	5
Ratanjyoti	3	3	4/5	4/5	5	4
Marigold	2/3	2/3	4/5	3/4	4	3
Teak Green Leaf	3	3/4	4	4/5	4	4
Acasia Skin	3	3	4	4	4	4

Conclusion

Natural dyes are not only having dyeing property but also having the wide range of antimicrobial and medicinal properties. Due to worldwide demand for antimicrobial textiles based on non-toxic and eco-friendly bioactive compounds, natural dyes can be exploited for imparting antimicrobial properties to textile substrates. Though natural colouration is known from ancient time as artisanal practice on handicrafts, painting and handloom textiles, the required scientific studies and proper documentations on characterization of dye-yielding plant and dyeing of textiles with natural dyes are still insufficient. To conclude, there is need for in-depth studies on characterization of dye yielding plants, methods of extraction of dyes and their applications and chemistry of interactions of such dyes with textiles materials for their commercial use for coloration as well as antimicrobial finishing agent.

References

1. Ramachandran, T., & et al (2004), Antimicrobial Textiles – an Overview, *IE (I) Journal – TX,* 84, 42-47.
2. Lim S H & Hudson S M , J Micromol Sci , Polymer Rev C43(2003) 223
3. Joshi M, Wazed Ali S &etal, Ecofriendly antimicrobial finishing of textiles using bioactive agents based on natural products. *Indian Journal of Fibre & Textile Research*. 2009; 34:295-304.
4. Aranaz I, Mengibar M, Harris R, Panos I, Mirralles B, Acosta N, Galed G and Heras A. Functional Characterization of Chitin and Chitosan. *Current Chemical Biology*. 2009; 3:203–230.
5. Gupta D, & etal, Antimicrobial activity of some natural dyes. *Dyes and Pigments* 2005; 66(2),: 99
6. Gupta D, Singh R, Jain A, Panwar S, Indian J of Fibre & Text Res, 30(2), (2005) 90.
7. Hussein, S. A. M., & etal, Tannins from the leaves of *Punica granatum*.*Photochemistry*1997,45, 819-823.
8. Gerson, H., Fungi toxicity of 1, 4-napthoquinones to *Candida albicans* and *Trichophyton mentagrophytes*. *Can. J. Microbiol*., 1975, 21, 197–205.

Demystifying the nature of spider silk and application of natural dye

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Abstract

Spider threads consist of long polymeric chains of protein molecules. These silk proteins are stored in the silk gland in a highly concentrated form until they are needed. The long chains with their repeating sequences of protein molecules are initially disoriented. Only in the spinning process the threads are oriented parallel to each other and form micro crystallites. Prof. Horst Kessler and his colleagues discovered that the individual spider silk proteins are first stored in the silk gland in small drops, called micelles.

Natural dyed spun silk carpets are very popular in U.S.A., Middle East and European market. Exclusive spun silk fabric produced from mulberry, tussar and muga pierced cocoons dyed with natural colours are very much popular in the export market.

***Keywords*:** Muga, Mulberry, Spider silk, Spun silk, Tussar.

Dyeing of silk fabric with onion peel waste using unconventional methods

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Abstract

The present study is an endeavor to make the process of dyeing with natural dyes cost effective through use of a waste product that is available in plenty, and through use of room temperature in the dyeing process. Attempt has also been made to improve the light and wash fastness of silk fabric dyed with onion peel extract. The effect of varying conditions of extraction and dyeing process variables (time, temperature, *p*H, MLR and dye concentration) on the surface colour strength on the related colour parameters and colour fastness of the dyed fabric has been assessed and optimum value established. Dyeing process variables like *p*H, temperature and dye concentration show a wide dispersion of CDI values indicating that these are the predominating dyeing parameters for dyeing silk fabric with onion peel. Also, darker shades of ochre were produced when dyeing was carried out under acidic *p*H. Increase in MLR and dye concentration intensified the tone of the colour. There is ½ - 1 grade improvement in the light fastness of silk fabric dyed with aqueous extract of the onion peel and subsequently treated with 2% UV-absorbers (benztriazole, benzophenone and MEK) by the pad-dry method. Also, 2% dye fixing agents agents (Tinifix WS Conc., cetrimide and CTAB) show some improvement in wash fastness of dyed silk when applied by the pad-dry process. Further with an objective to economize on the water consumption and use of fuel/energy, silk fabric has also been dyed with purified onion peel extract by the simpler dyeing process pad-dry-cure and pad-batch-dry. Pad-batch-dry method gives highest *K/S* values, and uniform dyeing results when 5 gpl dye concentration of the purified onion peel extract is used on silk fabric.

***Keywords*:** Natural dye, Onion peel, Silk fabric, UV-absorber.

Direct application of natural dyes on garments

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Abstract

With the world chanting the mantra of sustainability and going 'Green' for the health of the earth and its environment, fashion world is no alien to it. Fashion designers, manufacturers and retailers are busy developing 'green' ranges for people. Eco friendly natural dyed garments have scorched the ramps as fashion designers have rediscovered the beauty in natural dyes. However, the mass-market clothes are yet to get touched by natural dyes. The retailers are yet to display and sell natural dyed ranges in their stores. The manufacturers, in spite of seeing the hi-fashion natural dyed garments are restricted to use natural dyes in production due to some limitations. These limitations being, inconsistent colors shade by the lots of textiles. This paper explores the possibility of direct garment dyeing using natural dyes to avoid shade variation problems in mass production.

***Keywords*:** Environment, Fashion designer, Garment, Natural dyed.

Natural dye and its application on textile ——— an overview of present state of affairs

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Abstract

Natural dye provides an important alternative to petrochemical-based dyes in view of growing emphasis and globally nurtured concept of sustainable product and processes. It is therefore imperative that such dye should also be used on textile following environment friendly and energy efficient routes. Keeping such requirement for use of natural dye in focus, present article outlines briefly position of natural dye technology in respect of availability of resource, extraction process to be followed, application, fastness properties and other related advantages.

Keywords: Eco-friendly, Energy-efficient, Natural dye, Physiological property, Sustainable design.

Introduction

Natural dyes, made from plants, animals and shells provide important alternatives to petrochemical-based dyes and if harvesting is carefully managed, it offers environmental and social benefits including a low carbon footprint and valuable employment for rural communities[1-6]. They are not without disadvantages, however, predominantly linked to the dependency of natural dye processes on chemicals to fix the dye to the fabric and the difficulty of using natural dyes on an industrial scale. They in most cases are obtained in small amounts from large quantity of material, as concentrations of dye found in nature tend to be extremely low. Yet their higher cost, subtle colour variation and greater demands on time means that natural dye technology – as it stands today – has a particular cachet and quality that works well in small scale or specialist production**.** Use of such non-toxic, non-allergic environment friendly natural dyes find increased acceptance of the discerning consumers of the world , who look into well being, safety and health at the time of selection of textile that remain in contact with their skin during use[7-10]. In order to retain and increase our such share in the international market, it is imperative that natural dyed product should not only be made free from harmful chemicals but also should be produced following eco-friendly and energy efficient routes employing natural mordant and/or harmless inorganic salts. Keeping above requirements of natural dye technology in mind, scientists and researchers are putting their effort to minimize the drawbacks of the natural dye to make them competitive with their synthetic counterpart .Although, use of natural dyes for colouration of textile is presently confined only to handloom sectors and small scale exporters dealing with the production and sale of high valued textile[11,12], it appears from the continuous effort put by the scientific workers in refinement of the technology that there remains possibility of use of some natural dyes by the organized sector of the textile industry also in the near future. Present article gives a brief account of the recent status of the technology associated with application of such natural dyes, chiefly in India.

Availability of resources for natural dye

Important dye yielding plants in respect of availability in reasonable quantity in India has recently been reviewed and reported in the literature[13]. Tea (*Camellia sinensis*) is found to be of practical commercial significance in view of wide availability of waste tea leaf and potential of colouring components of tea to colour silk, wool and cotton with acceptable colour fastness properties following an eco-friendly route[14]. Onion skin (*Alleum Cepa*) is another widely available resource for natural dye in India[1], which can also be utilized for colouration of wool and silk fibres[1]. Henna (*Lawsonia inermis),* madder (*Rubia Cordifolia, Rubia sikkimensis*), marigold (*Calendula officinalis*) are the other sources of natural dyes which can be utilized also, in view of their wide availability. Other dyes worthy of mention in respect of availability in India are alroot (*Morinda citrifolia*), safflower (*CarthamusTinctorius*), patangwood (*Caesalpinia sappan*), Hemp (*Datisca cannabina*), palas (*Butea monosperma*), Turmeric (*Curcuma longa*), Annato (*Bixa orellana*), Dolu (*Rheum emodi*), Promegranate fruit rind (*Punica granatum*) Babul (*Acacia Arabia*) etc.

Extraction of dye from the natural resources

Colouring components or dyes from vegetable matter is usually extracted [15-20] by boiling the vegetable matter in water for a period ranging from 1-2 h. Colouring component from the same quantity of vegetable matter can be extracted more, if the vegetable matter is pulverized and/or steeped in water overnight prior to boiling. Extraction processes of colouring components from the leaves of Eucalyptus hybrid(*Cassia Tora and Grewia optiva*), cutch ratanjot(*Onosmas echiodes*) madder,hinjal jujube, jackfruit(*Artocarpus hetrophyllus*),marigold, chrysanthemum, saffron(Crocus sativus) and tea employing water as the extraction medium have been studied in detail and are reported in the literatures by the worker[21-23]. Solvent assisted extraction processes of natural dyes from the respective vegetable matters have also been done by the workers with varied degree of success[24-29]. Supercritical carbon dioxide has been found to be an efficient extraction medium of natural dye from the vegetable matter as reported by P.S.Vankar et.al[30]. A process for the extraction of carotenoid dyes from pre-dried natural starting materials is described using compressed gases such as propane and/or butane in which organic entraining agents can be additionally added in order to facilitate and complete the extraction process[31]. With the aid of this process highly concentrated carotenoid dyes are obtained in high yield. However for extraction in bulk following a cost effective route, the role of dyers traditional medium, water, remains most important and is being widely practiced. In view of presence of hydroxyl group in most of the natural dyes , alkaline aqueous extraction medium having pH 8-11 give high colour yield[32,33]. Such high colour yield in alkaline medium is obtained owing to the increased solubility of the colouring component in consequent to increased ionization of hydroxyl (phenoxide) groups in alkaline medium[14]. An addition of 1-2g/l of sodium carbonate to the aqueous extraction medium before boiling serves such purpose. Acidic pH causes phenoxide ion of the dye to be converted into phenolic hydroxyl group with consequent reduction of solubility of the dye molecule and pH of the extract is usually made acidic, when precipitation of the dye from the extract is done. The aqueous boiling extract of the natural dye so obtained is filtered and used subsequently for colouration of textile. However, the final application pH of the aqueous extract should be adjusted at a suitable level by the addition of acid or alkali for successful dyeing. It is however reported in the literature[34, 35] that for extraction of coluring components from red sandal wood and jatropha seed, optimum pH was commonly observed to be 4.

Application of natural dye on textile

Natural dyes cover a wide range of chemical classes, such as, indigoid, anthraquinone, alpha-napthaquinones, flavones, flavonols dihydropyrans, anthocyanidins, and carotenoids[1, 4]. Indigoid is natural vat dye and can not be readily applied on textile substrate unlike dyes belonging to other chemical classes mentioned above; indigoid is to be reduced and made soluble in water prior to its application on textile. After application of the soluble form of indigoid on textile, it is required to be oxidized to its insoluble form. Conventional reduction processes and dyeing methods have been discussed in detail by Gulrajani.et.al[1]. Most of the dyes belonging to chemical classes other than indigoid have medium to large conjugated linear and/or polycyclic structure in them with carbonyl, hydroxyl/carboxyl groups attached to it. When such dyes are applied on wool and silk fibres in absence of mordants from an acidic dyebath (pH~6-4), conjugated system of the dyes being hydrophobic in nature participates usually in hydrophobic-hydrophobic (Vander Waals) interaction with the hydrophobic part of the protein fibres and electron rich phenoxide ions of phenols/ polyphenols, carbonyl groups and/or carboxylate anions of the dyes are attracted by the protonated electron deficient – NH_3^+ groups of protein fibres[14,15,16, 36]. Studies done on the effect of variation in pH of the dyebath on the exhaustion for dyeing of wool, silk and cotton substrates with Camellia sinensis, Punica granatum, Bixa orellana colourants having different dye structures showed that, exhaustion of Camellia sinensis, Punica granatum and Bixa orellana from their respective aqueous solutions to wool and silk substrates were maximum under acidic condition and decrease with increase in dye bath pH; under alkaline condition (pH ~10), uptake of such colourants from their aqueous solutions by the protein fibres were found to be substantially less and protonation of both the fibres commonly resulted an increase in dye uptake. However, in view of known significant hydrolytic degradation of protein fibres at pH $\leq$ 2.5 under elevated temperature of dyeing for a prolonged time , the appreciable dye uptake at pH~4 observed for the above three colourants when applied on wool and silk fibre are of practical significance[37,38]. Dye uptake as assessed in such study in terms of percentage exhaustion of the dyed fabric appears to be commonly higher in case of wool than that observed in case of silk for all the pH and for all the above three colourants. This is due to the presence of more amino groups and higher amorphous regions of wool fibre as compared to those of silk. Report of a study on adsorbtion isotherm of Camellia sinensis, Punica granatum, Bixa orellana and Rheum emodi on wool and silk fibres showed that such dyes are adsorbed on protein fibres by more than one mechanism such as Langmuir and Nernst; Langmuir being responsible for ionic sites on the fibre in acidic dyebath pH and Nerst is for the Vandar Waals hydrophobic-hydrophobinc interaction between natural dye and protein fibres as described before.

The uptake of the natural dyes by the cotton fibres appear to be significantly less than those appear for protein fibres in absence of mordants. Cellulose in aqueous medium behaves as a weak acid due to the presence of hydroxyl groups in its structure. The hydroxyl group of cotton cellulose dissociates in water producing – CH_2O^- ion and the said dissociation of primary hydroxyl group leads to induction of negative charge on cotton. Vegetable colourants in general also have either phenol or carboxylic acid group in their structures. Such dyes with either phenoxide or carboxylic acid groups also dissociates in water producing respective anions of the colourants. An overall low natural dye uptake for cotton fibre reported[1] for natural dye is the consequence of repulsive effect operative between the dye anion and the negatively charged cotton fibre. Such repulsive effect however can significantly be reduced by the addition of common salt or glauber salt during dyeing. Most natural dyes can therefore be applied on cotton following a process similar to that used for direct class of dye from a neutral to alkaline dyebath; however in such case, fastness properties of the dyed cotton is observed to be poor and achievable depth of shade depends on the individual structure of dye.

Application of natural dye in presence of mordants

Presence of hydroxyl ,carboxyl or even carbonyl in the structure of natural dye give rise to the possibility of formation of insoluble salts under suitable condition with bivalent or trivalent positively charged metals. Also in some cases, associated tannin present in the colouring component may combine with such metals to form such insoluble salt. If suitably employed, bivalent and trivalent metals are capable of holding two or more of natural dye molecules together within the fibre structure. Incorporated dye molecules when aggregated in such manner within the fibre structure, can further stabilize themselves by the formation of intermolecular hydrogen bonds between two dye molecules and also between dye and fibre ; the said process ultimately lead to improvement in dye uptake and all round fastness properties of the dyed substrate[14,15,16,39]. Keeping environment related issues and adoption of cleaner technology in view, inorganic salts such as, aluminium sulphate, potash alum, and ferrous sulphate can be employed as mordanting agent in view of their good complex forming ability and environmental safe character. Use of tartaric acid and myrobolan as a source of tannin either alone or in combination with inorganic salts as mordanting agents are also reported in the literature[1, 49]. Aluminium sulphate or ferrous sulphate are reported to brings about change of the hue of the natural colourants, which can be utilized with advantage to produce different shades on protein and cellulosic substrates; a pre or post-mordanting method employing a 5g/l solution of the above salts at 70°C for 30-45 min would give optimum results.

Colour fastness properties

Light fastness property of most of the natural dyed substrates are found to be poor to moderate on wool showing light fastness rating of 2 to 4, with few exceptions, such as madder, indigo, pomegranate, tea etc., where a light fastness rating above 5 has been reported[1,14,15,16, 36]. Application of natural dye in presence of mordant such as aluminium and ferrous sulphate in general cause improvement in light fastness rating by half to two points depending on the textile substrate. Turmeric, fustic and marigold show poor light fastness property, which however can be improved significantly employing ferrous sulphate as mordant[40].Various attempts to improve light fastness rating of the substrates dyed with natural dyes have been reported in the literature[41-45].that include use of UV-absorber, benzitriazole, nickel hydoxy aryl sulphonates.

Wash fastness of the protein substrates dyed with natural dyes have been found to be moderate to good, which can further be improved by mordanting. Wash fastness of cotton dyed with natural dyes varies from poor to moderate depending on the natural dye. Colour fastness to wash can be improved significantly (by half to one unit) if, cotton is dyed with natural dye following a pre or post mordanting technique. Rub fastness of most of the natural dyes are found to be moderate to good and report of work related to improvement of rub fastness property is scanty or not available in the literature[40].

Physiological properties of natural dyes

Medicinal value of many of natural dye yielding plant found in India has recently been reviewed by R.Siva[13].Such plants are reported to be used for curing of variety of diseases. Some of such diseases are cough, bronchial infection, spleen and lever ailments, chest complaints, rheumatism, jaundice, fever, piles tumour, diarrhoea, skin disorder, dysentery, pulmonary disorder, leprosy, diabetes etc. Antimicrobial and antifungal activities of Punica Granatum (Pomegranate), Lawsone (Henna), juglone (Walnut shells), Acecia Catechu (heart wood), Rubia Cordifolia (Manjistha) have been identified and explained[46-49]. Also, carotenoid pigments have received considerable attention because of its role in the prevention of diseases such as prostate cancer[50, 51].

Conclusions

Natural dye provides an eco-friendly, energy-efficient alternative route for colouration of textile. There remains ample scope for further refinement of the available technology associated with natural dye to make it competitive with its synthetic counterpart. Identified medicinal value of many of the natural dyes further enhances its popularity and acceptance. It is therefore envisaged that such dye has the potential to play an important role in future, particularly in the light of worldwide growing emphasis on the philosophy of "sustainable design", if adequate knowledge-base is developed and sufficient data- base is created on eco-friendly extraction and application methods of natural dyes, employing further R&D efforts.

References

1. *Natural Dyes and Their Application to Textiles*, edited by M L Gulrajani & D B Gupta (Indian Institute of Technology, New Delhi), (1992).
2. J D Hill, *Rev Prog Col*, **27** (1997), p 19.
3. M L Gulrajani, *Indian J Fibre Text. Res*, 26 (3-4), (2001), p 191.
4. M L Gulrajani, *Colourage*, 46(7), (1999), pp 19-28.
5. B Glover, *Textile Chemist Col*, 27 (4), (1995), p 17.
6. T Dheeraj, T Priyanka and M Monica, *Colourage*, July (2003), p 35.
7. E M Dedhia, *Colourage*, 45(3), (1998), p 45
8. T Dheeraj, T Priyanka and M Monica, *Colourage*, July (2003), p 35.
9. R A Lal, *Colourage*, 42(1), (1995), pp 55-56.
10. S R Shukla, *Colourage*, 53 (8), (2006), p 75
11. R.B.Chavan, Colourage, 42 (4) (1995) 27.
12. R.B.chavan, Clothsline, 42(4))1995) 96.
13. R.Siva, Current Sc. 92(7), 2007, 916

14. D.Das ,S.Raymaulik and S.C.Bhattacharya , International.J.Tea.Sc.,4(2005)17
15. D.Das, S.Ray Mauik and S.C.Bhattacharya,Ind.J.F.Text.Res, 32 (2007)366
16. D.Das,S.Raymaulik and S.C.Bhattacharya.,Ind.J.F.Text.Res.,31 (2006)559.
17. R.Dayal and P.C.Dobhal., Colourage, 48(8) (2001)33
18. M.A.Khan,M.Khan,P.K.Srivastava and F.Mohammad,Colourage,56(1)(2006) 61
19. S.Saxena, P.V.Varadrajan and N.D.NaNachane, Proceedings Convention of Natural Dyes, Edited by Deepti Gupta and M.L.Gulrajani(Department of Txtile Technology,IIT,Delhi)2001,185
20. H.T.Deo and R.Paul, Indian .J.Fibre.Text.Res., 25(6) (2000)152.
21. E.G.Tsatsaroni and I.C. Eleftheriadis.,J.Soc.Dyers,Color,10(10) (1994) 313.
22. N.Verma and N.P.Gupta., Colourage,42 (7) (1995) 27.
23. N.C.Pan, S.N.Chattopadhaya and A.DayIndian.J.Fibre.Text.Res.28(9))(2003)339
24. B.nanda, A.Nayak, N.B.Das S.K.Patra,Proceedings,convention of Natural Dyes, Edited by Deepti Gupta and M.l.gulrajani(Department of Textile technology,IIT delhi)200,85
25. R.Bhuyan,D.C.Saikai and C.N.Saikai,Indain.J.Fibre.text.Res.,27(12) (2002)429
26. A.Agarwal, a.garg and K.Gupta, Colourage, 39(10) (1992) 43
27. N.V.Raja anf J.kala., J.Text. Assoc/, 66(3) (2005) 117
28. S.Eom, D.shin,and K.Yoon, Indian.J.Fibre.text.Res., 26(12) (2001) 425
29. K.Singh and V.Kaur, Colourage,53 (10) (2006)10
30. P.S.Vankar, V.tiwari and B.Ghorpade, Proceedings Convention of Natural Dyes, edited by Deepti Gupta and M.L.Glrajani (Department of Textile Tehnology,IIT Delhi),2001,53
31. H.Jurgon,C.Jan, W.Johann V Heinz Rudiger.,US patent 5789647,
32. R.sudhakar,K.N.Ninge and N.V.Padaki, Colourage 53(7),2006, 61
33. A.K.samanta, P.Agarwal and S.Datta,Indian .J.Fibre.Text.Res, 32(12)(2007) 466.
34. D.ruadhika and M.jacob.,Indain.J.Fibre Text.Res, 109 (7) (1999) 30
35. A.K.Samanta,P.agarwal and S.Datta,J.Inst Engg(I),Text.ngg,87 (2006) 16.
36. A. Johnson, *The Theory of Coloration of Textiles*, 2nd edn, (Society of Dyers and Colorists), 1989, 111.
37. M L Gulrajani, "Chemical Processing of Silk", edited by M L Gulrajani, Indian Institute of Technology, Delhi, (1993).
38. C L Bird, *Theory and Practice of Wool Dyeing*, (Soc Dyers Col, Bradford, England), (1982).
39. D.Das,S.Raymaulik and S.C.Bhattacharya, Indian.J.Fibre.Text.Res.,33,2008,163
40. A.K.samanta and P.Agarwal., Indian.J.Fibre.text.Res. 34(2009)384
41. C.C.Cook.,Rev.Prog.Colour,12 (1982)78
42. H.Oda,Colour Technol ,117(4) (2001),204
43. H.Oda,Colour Technol,117(5),(2001) 254
44. A.k.samanta,.Agarwal and S.Datta,J.text.Inst,100(7) (2009)565
45. D.Gupta,M.L.Gulrajani and S.Kumari .,Colour Technol, 120 (2004)205
46. S.A.Hussain,H.H.Barakat,,I.Merfo and M.A.Nawar,Photochemistry,45(1997)151
47. A.R.Schuerchand W.Wehrli.,Eur.J.Biochem 84 (1978) 197
48. R.Singh, A Jain, S.Panwan,D.gupta and S.k.Khare.,Dyes Pigm., 66(2005) 99
49. A.H.Gilani andK.H.Janbaj.,Phytotherapy,Res. 18(2004) 647
50. S.k.clinton.,Nutr.Rev., 56 1998 35.
51. A.V.rao and S.agarwal, Nutr,Res.,18,1999, 305.

Natural compounds and its medicinal activity

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Abstract

The worldwide demand for natural dyes is nowadays of great interest due to the increased awareness on different properties of natural dyes in public. Different kinds of active ingredients are found in extracts and are being used to impart various finishing properties. Many of the plants used for dye extraction are classified as medicinal and some of these have recently been shown to possess remarkable antimicrobial activity, UV protector, skin moisturizer etc. Future potential of natural dye and natural compounds and their application are critically reviewed.

***Keywords*:** Antifungal, Antimicrobial, Medicinal value, Natural oil, UV resistant

Introduction

Application of natural dye has been started since before, but after the innovation of the synthetic dye it is gone off focused. However, the synthetic dye itself or the dyeing process has some hazardous problems. So, considering the eco-friendliness of dyeing, natural dyes give us a large platform for research. However, recently there has been revival of the growing interest on the application of natural dyes [1-2] on natural fibers due to environment consciousness. Although ancient art of dyeing with natural dyes withstood the ravages of the time, a rapid decline in natural dyeing continued due to the wide availability of the synthetic dyes at an economical price [3-5].

The natural dye can be extracted from various resources such as for the vegetable origin the coloring matter is derived from the root, leaf, bark, trunk or fruit of the plants and it is believed that there are at least 300 plants from which coloring matter can be extracted [6]. But the non-allergic, non-toxic and eco- friendly natural dyes on textiles has become a significant importance due to increased environment awareness. Some of the natural dyes can also be applied on textile substrate as a compound for finishing agent. The use of natural products such as Chitosan [7] and few natural dyes [8-9] can be used as anti microbial, skin caring, anti ageing, skin moisturizer. Aloe Vera, tea trace oil, Eucalyptus oil, tulsi oil, Jojoba oil, etc[9] are commonly been used as a finishing chemicals. These natural products also have some kind of medicinal activities when they are used as natural colourants [10].

Natural dye ––– as an anti microbial agent

Many natural dyes obtained from various plants are known to have an antimicrobial property. The plants contain large amount of tannins viz. pomegranate (P*unica granatum*) and several other plants rich in napthoquinones such as henna, walnut etc. are reported to exhibit antibacterial and antifungal activities.

Curcumin as a common nontoxic natural dye used in textiles (Curcumin is brightly yellow colored) and as food has antimicrobial activity on wool [11]. Curcumin (also known as curcumin I) occurs naturally in the rhizome of *Curcuma longa*, is grown commercially and sold as turmeric, a yellow–orange dye. The antimicrobial of these dyes also depends on their chemical structure and specially their functional groups. Curcumin incorporates several functional groups. The aromatic ring systems, which are polyphenols, are connected by two α, β -unsaturated carbonyl groups. Curcumin can exist in several tautomeric forms. Curcumin has antitumor [12], antioxidant, antiartheritic, and anti-inflammatory properties [13]. Curcumin was also found to be a weakly fluorescent molecule and its fluorescence decay properties in most of the solvents [14].

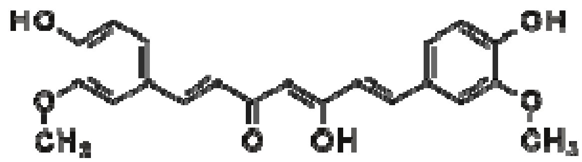

Fig.1 Chemical structure of Curcumin

Antimicrobial and skin care finish

The Aloe Vera has been using as a skin care for more than 2000 years. Aloe leaf contains 75 nutrients and 200 active compounds, including 20 minerals, 18 amino acids, and 12 vitamins. It is also composed of polysaccharides, mannans, anthraquinone, and lectins [15-16]. The polysaccharides chains with different long chain polymers consists of randomly acetylated D-mannopyranosyl units has antimicrobial, antifungal properties. The Aloe-Vera extract is applied on the cotton in various concentrations in presence of eco-friendly cross linking agent glyoxal in pad-dry cure technique [17].

The finishing agent inhibits growth of micro organisms by using an electrochemical mode of action to penetrate and disrupt their cell walls. When the cell walls are penetrated, leakage of metabolites occurs and other cell functions are disabled, thereby preventing the organism from functioning or reproducing [18].

Advantage of Micro-encapsulated Aloe Vera

Sensory Perception Technology™ seeks to take the finest Aloe Vera gels from the USA and through a unique process micro-encapsulate them, from recognized high quality sources approved by the International Aloe Science Council in Texas. Because the capsules are airtight and waterproof and are welded to the fibers during the Production textile process they, remain part of the structure of the textile and as the garment is worn or touched are able to deliver a constant stream of Aloe Vera as the capsules to the fibers and thence to the skin surface. The system has been successfully applied to hosiery and underwear, to create effectively self moisturizing garments [19].

Sericin as an UV Protector

Sericin is a second type of silk protein, which contain 18 amino acids, total amount of hydroxyl amino acid in sericin is 48.5%, there are 42.3 % is polar and 12.2% is non polar amino acid is present. It mainly envelope the fibroin and occurs mainly in an amorphous random coil, in β-sheet organized structure, which results in gel formation [20]. The Sericin is a bimolecule of great value as it is anti microbial, UV resistant; enhance the screening effect of UV filter like triazines, oxidative resistant and having moisturizing properties. Sericin containing membrane is Hydrophilic. Acrylonitrile used in making synthetic polymer can be copolymerized with sericin to prepare a protein containing synthetic polymer film used for separating water from organics [21]. Some of the functional properties of synthetic fibres is also improved such as the sericin modified polyester in which polyester become five times more hygroscopic than normal polyester [18]. It has been found that sericin treated with (4%w/v) PET fabric shows 51% reduction of *p.vulgis,* 38% reduction of *S.aureues* [22], and has a potential of such applications.

Finishing with different natural oil extract

There are few natural oil extracts which also can be used for finishing of textiles materials for their different medicinal activities. Most of the natural oils are used for their antimicrobial activities, some of them are used as the moisturizer here we mention few them with their different activities Such as *Onion skin* and *Pulp extract, Clove Extract, Tulsi Leaves, Eucalyptus oil, Prickly chaff Flower, and Jojoba oil.*

***Neem extract*:** More than 300 compounds are found, among the different parts of the tree most important limonoids are azadirachitin, salannin, nimbin [23]. They inhibit the bacteria attack; few patents are based on the use of neem oil using microencapsulation technique [24], applying on cotton [25] and cotton/polyester [22]. Neem bark extraction is also used in wool dyeing [26].

***Tea tract oil*:** It contains more than 100 compounds. Its oil is considered to have best natural antiseptic and anti fungal properties. This oil is also active against few bacteria also.

***Azuki beans*:** White extract of Azuki beans shows inhibition towards microorganisms, coloured extract contain large amount of polyphenols shows anti microbial activity [27].

Chitosan

Chitosan is produced commercially by deacetylation of chitin, Chitosan are primarily sourced from shrimp and crabs industry. Those are the waste products from these industries. Chitosan can be applied to the textile industry as an antimicrobial finish and it became popular due to its ability to provide protection against allergies and infectious diseases. The prime focus for chitosan as an antimicrobial treatment has been on cotton. Early work indicated that the antimicrobial effect was potent against a range of microbes, but the finishing was not durable [28] and to improve its durability, chitosan has been cross linked to cotton by using different cross-linking agents viz. dimethylol dihydrox-yethyleneurea (DMDHEU), citric acid, 1,2,3,4, butanetetracarboxylic acid (BTCA) or glutaric dialdehyde [29-30].

Meheta, et.al [31] reported that chitosan can improve the dye coverage of immature fibres in cotton dyeing and that it could be successfully used as a thickener and binder in pigment printing of cotton [32] and can also minimizing creases in cotton fabrics. Kuo-Shien Huang et.al. [33] used H_2O_2 to degrade chitosan to low molecular-weight chitosan (LWCS), which was then mixed with an anti-creasing agent (dimethylol dihydroxyl ethylene urea) and then applied on the cotton fabric. The result shows that the anti-wrinkle property of all finished fabrics decreases after 20 wash cycles. The softness of the fabric was improved, and the strength of the fabric decreased slightly after the wash treatment to cross-link the cellulose molecules in the fiber. In wool finishing, chitosan has been used as a shrink resistant agent [34-35] and as an agent for improving the dye ability of wool [36-37]. The modified fibre always shows somewhat different dyeing behavior.

Medicinal activity

When we consider the natural dyes and it application, there many different types of natural which can be not only used in textile industry but they are also are commonly used in the cosmetic industry due to no side effects, UV protection and anti-aging properties. I n India, there are more than 450 plants that some of these plants also possess medicinal value. Natural dyes are environment friendly for example, turmeric, the brightest of naturally occurring yellow dyes is a powerful antiseptic which revitalizes the skin, while indigo gives a cooling sensation[10]. There are other plants with various kinds of medicinal activities[38] which is not covered in this article.

Conclusion

There are vast resources of natural products which can be used as finishing agents for antimicrobial, anti bacterial, antifungal, UV protection etc. where all kinds of textile finishing are still not possible with natural products. But the continuous development of natural dyes makes it possible for using natural dyes over the synthetic dyes due to their eco friendliness and environment consciousness. Natural dyes are not only having dyeing property but also having wide ranges of medicinal properties. The natural oils can also be applied in textiles as a finishing agent or in the micro encapsulation technique; the treated fabrics can be used for textile application. To conclude, there is need for proper methods, documentation and characterization of dye yielding plants for further development.

References

1. Kamat SY & Alat DV, *IndianText.J* (3) (1990)66.
2. Glover B, *Text Chem Colour* 27, (4), 1995 17.
3. Smith R & Wanger S *Am Dyest rep* 80 (9) 1991, 32.
4. Dably G, J *SOC of Dyers & Col* 109(1) 1993.
5. A.K. Samanta & P. Agarwal *IJFTR,* Vol 34, Dec 2009, pp 384-399.
6. Dr R.B.Chavan *revival of natural dyes* 181.
7. Lim SH and Hudson SM, *J macromol Sci. Polym Rev* C43(2003) 223.
8. Gupta D,Khare SK, & Laha A Coloration tech 120 (4) 2004, 167.
9. Gupta D,Khare SK, & Laha A Coloration tech 120 (4) 2004, 167.
10. R. Siva *CURRENT SCIENCE*, VOL. 92, NO. 7, 10 APRIL 2007

11. Fernandez MA, Garcia MD, Saenz MT J Ethanopharmacol 53, 1996, 11.
12. Bharat B. Aggarwal, Indra D. Bhatt, Haruyo Ichikawa, Kwang Seok Ahn, Gautam Sethi, Santosh K. Sandur, Chitra Natarajan, Navindra Seeram, and Shishir Shishodia, 7034_book.fm Page 297 Monday, July 24, 2006.
13. Stix, Gary Feb 2007, *Scientific America.*
14. B.B. Aggarwal, D.Bhatt, Chitra Natarajan *7034_book.fm* Page 297 Monday, July 24, 2006.
15. Boudreau MD, Beland FA, *Jour of Enviornmetal Sci & health Rev* 24 (1) 103-108.
16. Vogler BK, Ernst E oct 1999 *J. of the Royal Colleg.* 49 (447) 823- 835.
17. M. Joshi, S.wajid Ali, & R. Purwar *IJFTR* Vol 34, Sept 2009.pp295- 304.
18. D. Jothi *African Journal of Microbiology Research* Vol. 3(5) pp. 228-232 May, 2009.
19. Sensory perception tech. IFF, DCH May 2004.
20. MN.Padamwar & AP.Power *J.of Sci & Industrial Research* vol 63, Apl 2004 pp339-329.
21. Yamada &Fuwa 1994 Yamada et al, 1993.
22. Brama K.P *finishing of polyester with Sericin* M.Tech dissertation IIT Delhi, 2006.
23. Schutter H, The Neem tree: Source of unique natural product (VCH.Germany), 1995.
24. Nathalie C Wo Pat 03002807, 2003.
25. Purwar, M. Joshi,Misra P AATCC Rev 8 (2) 2008 35.
26. M. Joshi, S.wajid Ali and Rajendran S J Appl Sci106, 793, 2007.
27. Hori Y,Sato S & hatai phytother Rev 20, 2006,162
28. Lim S H and Hudson SM, *J macromol Sci. Polym Rev* C43 (2003) 223.
29. K.FE.L Tahlway, E.L.Bendary, S.M. Hudson *Cobohy. Polym* 60,421 430, 2005.
30. Y.S Chungl.Chen,L.hung *Tex Res J*,72, 1103-1106, 2003.
31. R. D. Meheta, R. Combs, *American Dyestuff Reporter*, **86**(7), 43–44 (1997).
32. S. A. Bahmani, G.C. East, I. Holme, *J. Soc. Dyers Colourists*, **116**, 94–99 (2000).
33. K. S. Huang, W. J.Wu, J. B.Chen,H. S.Lian, *Carbohydr. Polym*, **73**, 254–260, (2008).
34. M. R. Julia, E. Pascual, P. Erra, *J. Soc. Dyers Colourists*, **116**, 62–67 (2000).
35. M. S. Masri, V. G. Randal, A. G. Pittma, *Use of crosslinked chitosan in the finishing treatment of wool fabric for launderingshrinkage control.* 1978, pp. 306–311.
36. B. Fillipowaka, A.Walalwska, E.Rybicki, *Teinture et chitosan. L'industrie Textile*, **1323**, 79–81 (2000).
37. N. Onar, M. Sariisik, *J. Appl. Polym. Sci.*, **93**, 2903–2908 (2004).
38. B.Chengaria, K.Mallikarjuna Rao, K.Mahesh kumar, *International Journal of PharmTech Research,* Jan-Mar 2010, Vol.2, No.1, pp 144-154.

Table 1: Quantitative analysis test results of treated and untreated sample[18].

Bacteria	Finishing agent concentration in gpl	% of bacteria reduction after treatment
Staphylococcus	1	97
	2	97.9
	3	98.1
	4	98.4
	5	99.1

Table 2: List of few natural dyes with their medicinal activities

Plant	Parts used	Colour obtained	Pigment	Medicinal properties
Acacia catechu Willd.	Bark	Brown/ black	Catechin, Catechutanic acid	Used medicinally for sore throat and cough.
Adhatoda vasica Nees.	Leaf	Yellow	Adhatodic acid, carotein, quercetin	Used in bronchial infection
Aloe barbadensis L.	Whole Plant	Red	Barbaloin, aloe emodine	Fresh juice of leaves is cathartic and refrigerant used in liver and spleen ailments and for eye infections , useful in X-ray burns
Indigofera tinctoria L.	Leaf	Blue	Indirubin, Indican	Extract used in epilepsy and other nervous disorders; in the form of ointment used for Sores, old ulcers and piles.

Eco-friendliness of natural dyes

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Abstract

Though natural dyes are extracted from the natural resources, some of the sources and dyeing practices may not be entirely 'green' with respect to health and environmental issues such as presence of pesticides in plant materials, salts of heavy metals (mordants) used in dyeing, etc. Use of forbidden heavy metals as mordant should be restricted as per permissible limit value. Eco-friendliness of natural dyed products should be determined as per eco-norms specified for textile products based on Life Cycle Assessment (*i.e.* 'cradle-to-grave' approach). Since testing and certification system as per eco-standards will certainly restrict the use of harmful substances at each stage of production process.

Keywords: Aquatic and oral toxicity, Banned aryl amines, Eco-standards, Eco-toxicity of dyes, Environmental friendly, Fixation, Low impact dyes.

Introduction

Until 1890, all available dyes (pigments and tannins) were from "natural" (i.e. mineral, animal, microbial or vegetal) origin, simply processed by chemical, biological or physical processes. Natural dyes were probably discovered, when the first man picked the first berry. The discovery of man-made synthetic dyes late in the 19th century ended the large-scale market for natural dyes. Mauveine, the first synthetic dye was accidentally discovered in 1856 by William Henry Perkin, who was trying to synthesize the anti-malaria drug. In one of his "failed" experiments, the aniline reacted with toluidine impurities in it and produced a black solid. While cleaning the flask, he discovered that black solid residue which proved to be an effective dye for silk and other textiles.

Genesis, advantage and problems of natural and synthetic colourants are highlighted on Table-1.

Some 'experts' talk about various problems (land for growth, poor technical performance) of natural dyes and others focus on advantages of technologies based on sustainable resources.

Ecotoxicological aspect of natural dyes

The most environmentally friendly way of dyeing textiles is one which does use low impact or non toxic chemicals, etc in the process. Majority natural dyes need application with a mordant (salts of Cr, Sn, Zn, Cu, Al, Fe) to effect satisfactory wash and light fastness and to give good colour build-up. Effluent therefore contains heavy metals far in excess of allowable limits under Pollution Control Act.

Only one or two natural dye has been identified as posing potential problems. For example quercetin is considered to mutagenic. On the basis of study of some natural dyes like Katha, Jackfruit wood, Turmeric and Indigo show the presence of arsenic, lead, mercury, copper and chromium less than 0.2 ppm which is much below the stipulated limit except for chromium. Very little work has however been carried to assess the toxicity of natural dyes.

The presence of the banned aryl amines in natural dyes is excluded as most of the natural dyes are based on quinones, flavonoids anthraquinones, alkaloids, napthaquinone etc. and not based on azo-linkages.

Dyes have been extracted from plant material by a number of methods, not all entirely 'green'.Contamination of pesticides may occur during the growth of natural dye yielding plants from soil or storage. In view of this, the best way to evaluate Eco-friendliness of natural dyes is ——— Life Cycle Assessment (LCA) of the whole textile dyeing process will be essential to demonstrating the sustainability of this proposed system. In LCA, one is to consider the complete process beginning with the raw materials and ending with the waste management i.e.

- Raw materials (use of pesticides in the cultivation of the raw material)
- Production process (water & energy saving)
- Transport including packaging
- Use of the product (limited amount of harmful substances in the product)
- Waste management (recycling)
- Disposal

The 'cradle-to-grave' approach is proving difficult to use, as the number of variables that the analysis must take into consideration is huge.

Hence, most of the eco-labels which are already in the market consider only a single phase of this process like the production or the use of a product (Table-2). In these, textiles and if necessary the associated production processes are also tested according to particular criteria in order to decide whether an eco-mark is issued or not. Eco-friendliness of natural dyes is done by assessing the eco-parameters viz. toxic heavy metals, pesticides formaldehyde, pentachlorophenol, etc as per national (Ecomark) and international certification system or Eco-norms for textiles such as Ecomark, Oeko-Tex Standard 100, etc.

During work out of these standards, different chemicals used in textiles were taken into consideration, out of which the following are of relevance to dyeing:

- Heavy Metals
- Azo dyes which release carcinogenic amines
- Toxic Pesticides
- Pentacholrophenol
- The pH of the aqueous Extract
- Product

The permissible limits of the above mentioned elements are given in Table-3 and 4.

Conclusions

Natural dyes of vegetable origin are safe and environment friendly to dye natural fibre as natural dyes are virtually free from harmful chemicals. Use of forbidden heavy metals as mordant should be avoided or may be applied as per permissible limit value.

The best way to evaluate natural dyes is therefore through testing and certification system as per eco-standards that restrict the use of harmful substances at each stage of production processes, without affecting the desirable functional properties (e.g. colourfastness) of the textiles. Testing criteria are pH-value, pesticides, heavy metals, etc.

Opportunities for further research work on natural dyes —– a few suggestions

- Develop a range of natural and environmentally safe textile dyes.
- Develop environmentally friendly extraction and concentration methods.
- Standardise natural dyeing processes to achieve bright color and high colourfast dyeing on natural fibres.
- Use of non-metal mordant to enhance the above mentioned parameters.
- Develop new techniques of fixation using non-metal mordant.
- Chemically modify natural dyes to improve colourfastness as well as to obtain full colour gamut (range of shades) on a variety of natural fibres.
- Toxicology of successful natural dyes needs to be investigated extensively.

Table-1: Implications of Natural and Synthetic dyes

Elements	Natural dyes	Synthetic dyes
Production	Nature or from agriculture (renewable resources)	Petroleum origin (finite resources)
Advantage	Environment friendly or low impact dye	Diversity of colours, regulated (mastered) quality, reproducibility
Problems	▪ Vast lands were needed to meet world demand	▪ Toxic or dangerous chemicals or intermediary products
	▪ Raw material and End-products: variable in quality, limited in quality	▪ Environ mental Pollution
	▪ Exploitation diversity: Overexploitation of species	▪ Aquatic and oral toxicity
	▪ Environmental pollution(air, water, soils, …) by dyestuffs preparation processes, …	

Table-2: Toxicological properties of end product vis-à-vis ecological aspects of the production process

Ecological aspects of the production process	Toxicological properties of end product (Based on human ecology)
• Extraction & production of fibres • Eco-toxicity of dyes & auxiliaries and their toxicological effects on humans • Quantity of water, energy, chemicals/ auxiliaries used • Quality of air and purity of water, noise pollution, waste disposal and recycling • Amount of harmful substances in the product • Packaging and transport of goods • Disposal ecology • Social aspects such as wages negotiation, working hours, working conditions, prohibition of child labour & social security.	• Residual pesticide within limit value • Free from toxic pesticides / antiseptics • No use of heavy metals • pH value favourable to skin • Free of allergy causing dyes • No application of dyes which are known to be carcinogenic or liable to cause cancer • Free formaldehyde as per stipulated limit • Good colourfastness to water, washing, rubbing and perspiration

Table-3: Permissible limits for home textiles/outer fabric (in PPM or mg/ Kg)

Criteria	Eco-mark for jute (India)	MST (German)	Oeko Tex Standard 100 (Austria)	Clean Fashion (Private Cos. Dealing with textiles)	Steilmann (Prominent German Textile Co.)
1. Azo-dyes containing carcinogenic aromatic amines	30.0	Ban	Ban	Ban	Ban
2. Heavy metals	- - - 0.1 50.0 - **10 (Sum parameters as lead)**	As- Cd- Co- 0.2 Cr+++-0.1 Cu- 3 ‘’ Pb- Hg- 0.001 Ni- Zn-	1.0 0.1 4.0 2.0 50.0 1.0 0.02 4.0 -	- - - 20 50 - 0.1 - -	- - - 0 - - - 1.0 -
3. Penta-chlorophenol	0.5	0.5	-	0.5	Ban
4. Residual pesticide (sum Parameters)	1.0	1.0	5.0	1.0	1.0
5. pH of aqueous extract	6.0- 7.0	4.0- 7.5	4.0- 9.0	-	-

Table-4: Eco-standards for product behaviour in use

Parameter	Comitextil	MST	Oekotex	Ecomark
Water	3	-	3	-
Washing	3	-	3-4	-
Perspiration	3	-	3-4	-
Dry Rubbing	3	-	4	-
Wet Rubbing	2	-	2-3	-

Opportunities of natural dyes for a greener textile and colouration industry

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Abstract

Dyes obtained from natural sources, such as plants and insects, have been used for decorative effect and as symbols of status for thousands of years. The mollusk-derived Roman purple (dibromoindigo) also called as *Tyrian purple*, was remarkable for its fastness to light and washing and it was also an important mark of social distinction. The associated biblical blue holds great religious significance among observant Jews. In China, the emperor and empress wore yellow, the imperial ladies wore violet and the noblemen of the first grade wore blue. In America also there were many natural dyes, particularly dyewoods, which were not previously known in Europe. Native American peoples like Navajo and Hopi were highly skilled dyers. In Europe the blue extracted from the woad plant was used for adornment through the colouring of skin and later the dyeing of textiles. By the sixteenth century dyes played a major role in political and economic history because European nations vied for sources of new colors and the secrets of applying natural colours. *Indigo tinctoria* that yielded a brighter indigo blue than woad arrived in Europe from India and the East. Indigo and the red known as madder obtained from the roots of the madder plant were the most important natural dyes. Indigo was used in kimono dyeing in Japan. Madder was the basis of the fiery Turkey red. King of England George II chose indigo for the color of British naval uniforms (hence "navy blue"). Lac and Cochineal dye are also included in this time.

***Keywords*:** Biblical blue, Kimono, Status, Turkey red, Woad

Introduction

In human life textile goods are very much essential in everyday life. We all know that synthetic colourants can be harmful for the persons directly involved in manufacture and sometimes cause allergies in human body, but there is no such harmful effect in case of natural dyes. Natural dyes are of heritage importance due to their eco-friendliness and environ-friendliness. It has high demand particularly in foreign countries like France, Korea, Japan, England, and Italy and also in India though limited within an elite class of people. The main reason behind it is the high price of the dye and the products dyed from it. The reason of high price is also inadequate supply of dyes against the actual requirement for the huge population of the world. Even then, natural dyes are mostly consumed by the handloom sectors as the consumption of dyes are much low in comparison to big industries. Here the natural dyes are based on a new manufacture technique completely in an eco-friendly manner mostly from vegetable wastes or renewable sources to decrease the cost of dye to at least 50% of the present market. Naturally the handloom products will be affordable by the common people in the indigenous market also. Natural Vegetable dye and handloom fabric, thereof, will have good demand not only abroad but also in the indigenous market. As the fabrics dyed with natural dyes contain eco-friendly metals in the form of color lakes, an antifungal as well as antibacterial property is also grown up when the human skin is saved from skin disease even in humid hot condition. Indian silk and wool industries should step forward and take the challenge for global demand of natural dye. It will also help the other small and big manufacturers of natural dye in India. The major consumers of vegetable dye-stuff are Carpet Industry located at Bhadoi and nearby areas, and also Silk producing areas scattered in and around Varanasi and Kanjivaram. There are lots of small dye houses in India who are using the natural dyes. Aura Silk house is one of them. The sector wise consumption of vegetable dye is given in Table 1.

Specialty of ECO –N- VIRON products

Generally natural dye application is very time consuming process as the raw resources need to be crushed, boiled and then filtered and finally dyeing is followed. Here the natural dye is of a special kind which is water soluble and ready to use for dyeing as well as printing in most innovative method. Most important it is that the dye can be stored for more than three years without any growth of fungus which is the main enemy for spoiling natural dyes. The manufacturing and preservation technique of natural dyes is waiting for patent. The names of the Textile Auxiliaries and Natural Dyes with trade names are given in Table 2 and 3.

Materials for dyeing

Textile goods like Silk, Wool, Cotton, Jute etc can be dyed by these dyes. Even leather can be dyed by using special method.

Chemicals and Reagents used for dyeing of textile materials

Soda ash, Glauber's salt, Sodium Nitrite, Sulphuric Acid, Alum, Ferrus Sulphate, Acetic Acid, Sodium Hydrosulphite and Hydrogen Peroxide (all of commercial grade) should be used as and when necessary.

Normal Dyeing Process

30 - 50gm/ lit dye is taken in a dye bath and the temperature of the bath is raised at 50˚c. Then silk/wool/jute yarn or fabric is put into the bath and dyed for 15 - 20 minutes at the temperature of 80˚c with addition of 2gm/lit Acetic acid for better dyeing and absorption of dye. Cotton yarn dyeing process remains same but Acetic acid is not to be used.

Mordanting and Development

Mordant class natural dyes need a metal salt to create insoluble coloured lakes inside the fiber according to necessity of shade. These salts are known as "Mordants". Only Alum [$AlK(SO_4)_2$], and Ferrous Sulphate ($FeSO_4$) should be used here to get different shades. The quantity of mordant salts is taken $1/6^{th}$ of natural dye used and treated at 60˚C for 15 mints. The mordating process should be post mordanting to get the best result. It should be remembered that the premordanting and simultaneous mordanting processes are totally unsuitable for silk, wool and cotton fiber. There is no question for mordanting Indigo dye as it is a vat class natural dye. Only 10gm/lit Sulphuric Acid and 10g/l Glauber's salt at 50˚C is required for developing (silk/wool) the blue shade of indigo. Hydrochloric acid and common salt should not be used for developing the blue shade of Indigo dye in case of silk and wool materials, but it is suitable for cotton. Sulphuric acid and Glauber's salt are suitable for these protein materials.

Aftertreatment process

The dyed material should be aftertreated with non-ionic detergent. It is a necessary procedure to remove remaining surface dyes and chemicals after dyeing. First cold wash then soaping with 1gm/lit Non-ionic detergent for 10 mints at 50˚C is normally done. The dyed yarn and fabric should be dried in shade particularly for natural class dyed materials. Softener may be used for better finishing, if required.

Conclusion

The dyeing process of natural dye should be very simple as well as scientific for implementation in Textile Industry. Natural dye has now been survived not only in cottage sector but also tends to enter medium size Textile Silk and Wool Industries. Hence training workshop and awareness programme on natural dye are necessary to be undertaken. Governments of all countries are encouraging to take some initiatives to save the heritage dye because the dyes are not only eco-friendly but also environ-friendly and will be helpful to balance the green-house gases due to more cultivation of plants and trees.

Reference

1. www.en.wikipedia.org/wiki/Natural_dye
2. Conffrancesco Aj (1995) Dyes, Natural.In: Encyclopedia of Chemical Technology, 4th Ed, Vol 8, pp 784 – 809, John Willey & Sons, New York

Table 1: Vegetable Dye State wise Consumption

Sl. No	State	No. of Artisans engaged in vegetable Dyeing	Expected meters of cloth dyed/ annum in lakh	Quantity of dye used in tones	Requirement of raw material in tones
1	Andhra Pradesh	350	10.50	52.50	2620
2	Orissa	550	16.50	82.50	4120
3	Assam	600	18.00	105.00	5250
4	Arunachal Pradesh	400	12.00	75.00	3750
5	Manipur	300	9.00	45.00	2250
6	Meghalaya	300	9.00	45.00	2250
7	Rajasthan	1000	30.00	150.00	7500
8	Karnataka	400	12.00	60.00	3000
9	Himachal Pradesh	250	7.50	37.50	1870
10	Uttaranchal	150	4.50	22.50	1120

Table 2: Textile Auxiliaries

Trade Name	Applied Area	Purpose
Scourex-c	Any kind of silk yarn/fabric	Silk Degumming
Scourex-n	High quality silk yarn/fabric	Silk Degumming
Scourol	Any kind of wool yarn/ fabric	Wool Scouring
Encon	Any textile material	All kinds of soft soaping
Ecosoft-k	All type of natural fabric	Softening of material

Table 3: Natural Dyes and shades obtained

Dyes Trade Name	Origin	Al	Fe
TERBULA	Harda	G-Yellow	Ash, Black
CURCUMA	Turmeric (Modified)	Lemon yellow	Blackish yellow
CAMENCIS	Tea Leaf	Brown	Ash
LAWSON	Henna	Brown	Deep-ash
RUBICUR	Lac & Turmeric	Orange	Brown
RUBITIN	Manjistha	Orange	Brown
ALCEPA	Onion skin	Poppy	Green
TERMINA	Arjuna bark	Brown	Ash/Black
PUNICAN	Anar peels	Reddish yellow	Ash/Black
LACCA	Laccaica	Pink/Red	Reddish Violet
ROYAL	Indigo plants	Royal blue (Vat Class dye & not prone to mordants)	

Traditional Indigo Dyeing

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Abstract

The process of indigo dyeing, though known for centuries, has been a closely guarded secret of few craftsmen. In this paper, some of the secrets have been analysed scientifically. This paper describes how to put up an Indigo vat and sustain it. It is the outcome of a 3-year long research work at the Dyeing Studio of National Institute of Design. It describes some important factors hitherto have not been articulated.

***Keywords*:** Clay vat, Indigo, Indican, Natural fermentation, Oxidation, Sukomo, Woad balls.

Introduction

Any textile older than 100 years, if it has blue in it, it is most probably indigo. Though there could have been few other dyes that could give blue, Indigo never had any sort of competition from them. It had its own charm when it came to the Indigo. Indigo used in textiles of near east and India shows that it has many good properties, in the desserts of Kutch, Thaar, sub-Saharan Africa and dry lands of south-western Asia and Turkey. The great civilizations such as Indus Valley, and Mesopotamia, and Nile valley had indigo blue in their textile palette. So, indigo is the Blue of the old world.

The name 'Indigo' suggests that the craft of extracting the dye and dyeing was practiced in India by many craftsmen, since probably more than thousands of years. The knowledge of indigo dye's science, its extraction, and the art and technology of dyeing was mastered and probably disseminated to other parts also. There are instances where indigo is referred to as a mood, raga in old religious scriptures, epics, and literature of India. For a very long time till the invention of the synthetic Indigo, India was the largest producer and exporter of Natural Indigo.

There are as many as 40 plant species capable of producing indigo in India. Indigofera species is mostly used in India and Africa. *Strobilanthus flaccidifolius* or *Baphicacanthus Cusia* of Northeast India and *Polygonum* of Japan, *Isatis tinctoria* or woad of Europe are the famous ones. Though little known, the madras indigo or the pala indigo, *Wrightia tinctoria* is also one of the plants that contains indican, the precursor for the formation of the Indigo dye.

Indigo dyeing has been a common practice in various forms at different parts of the world, like the direct dyeing methods of northeast India with the leaves of *Baphicanthus cusia* popularly known as Assam or Naga Indigo and alkaline ash water, which is also practiced in parts of china and Indonesia. In India, Indigo dyeing was done by fermenting the dry indigo cakes extracted from the plant in a vat set or installed into the earth along with alkaline lime.

The fermentation breaks the dye to dissolve in the water and to be able to dye. Though a long tedious process, it is still in practice at some places in India and at different parts of the world. There is another way of dyeing the indigo which is practiced in Japan, is by preparing the *sukomo* or Indigo balls by pounding the Indigo leaves of *Polygonum tinctorium* and fermenting them and dyeing, the difference being less time taken for fermentation in this case. Similar to this sukomo, is the dyeing with the woad balls practiced in Europe, and the indigo dyeing traditions in West African countries like Mali.

Indigo, when dyed does not join to the material or the fibre chemically, but is attached to the material by physical adhesion in case of cotton, and this adhesion is little stronger in case of silk or wool. This phenomenon of Indigo makes the cloth dyed with indigo to be less resistant to abrasion on the surface which gives various shadings and tonal values, which is popularly exploited in the denim wears as the "faded jeans" look.

Putting up a Natural Indigo vat involves many things right from selection of pot to the right placement and starting the fermentation and sustaining it.

PIT

As it was thought of having a natural indigo fermentation vat, the first thing was to think about the space where we could probably dig the pit for the vat. The lean clay vat of approximately 80 to 100 liters would be immersed almost its full height deep in the earth. The factors that helped in locating the space to dig the pit and put up the vat were

- Enclosed place to avoid direct fresh air full of oxygen to come in contact with the surface of the vat, to avoid oxidation of the ferment- reduced dye which would consume time and energy that have been put in the preparation.
- The space that has immediate opening or a place nearby full of fresh air, for oxidizing the dyed fabric in the indigo vat as soon as it is taken out from the dye vat to avoid any uneven oxidation.
- The earth that can be dug easily deeper than the height of the proposed vat.

First, we thought to finalise a space within the walls with concrete floor but, when the concrete flooring of at least 8" thick became our hindrance to dig the pit of about 3ft. deep, we dropped the idea of having a vat in the studio, and then started looking for other spaces that would be fit.

Then, we thought if there could be immediate environment for oxygen, and we could have some secure place, we found a place with walls on two sides and other two sides open. In consultation with one of craftsmen, the space was finalized and a pit of 3ft in width and length and 3 ft. deep in earth was dug. Putting up a vat in open space without any enclosure was a risk. May be there would be more chances of the vat getting contaminated and spoiled easily both by the nature of open environment and frequent changes in temperature mainly and others. The craftsman's view was that he has his vat in open space and it might not create any great problem. But, what we both agreed was to put the vat under constant supervision and, if necessary, some arrangement could be made for securing the vat by covering it with a lid.

VAT

Selecting appropriate vessel to be buried under the earth for fermentation process has also been a challenge and a huge task on hand. Material properties of various materials used for vats in various places were studied. Traditionally it has been made mostly of clay or wood. But, today lot of dyers use plastic vats.

The clay vat was finalized with a narrow flat bottom, and wider top; the opening was narrower than the diameter of the top half of the vat and wider than the bottom, opening was just enough to enable the material and the hand to move easily. The narrow bottom is approximately one fifth of the vat's total height. This one fifth part has a curved intersection profile which allows the undissolved and unfermented particles of the indigo dye as well as other solid particles that are added to the vat intermittently like lime, ash, dates, jaggery, seeds of *Cassia tora* or other materials and also the solid particles formed from time to time during the currency of dyeing to settle down.

There are also intricacies regarding the form of the vat that is used for the Indigo process. In olden days the clay vats were made custumised as per the requirement of indigo dyers specially. The form of the clay vat was with a narrow flat bottom, and wider top with the opening that is narrower than the diameter of the top half of the vat and wider than the bottom, just enough opening so that the material and the hand can be in motion at ease. The form of the vat was like the narrow bottom would be approximately one fifth of the vat's total height. This one fifth part has a curved intersection profile.

During the fermentation in the vat calcium and other complex salts are formed due to the presence of calcium, which reacts with sugar present in the vat. These salts do not easily dissolve in normal conditions of the vat. All these things would settle down at the bottom part of the vat once the vat is still. The form of the vat greatly influences this particular happening. If the vat is wider at the bottom, the solid undissolved particles would settle down fast, but would also come up to the dyeing surface very easily. So, it is good if the vat is narrow at the bottom. The undissolved Indigo and other solid particles in the vat may occupy about one fifth of the total volume or approximately one fourth of the height of the vat. It is essential that the form of this one forth height from the bottom, should enable the solids to settle down easily and also reduce the amount of solids to come to the dyeing surface as little as possible. The bottom is also the source of heat and fermentation that is constantly continuing to the whole life span of the fermentation Indigo vat.

Preparation of the fermentation 'Vat'

Considering the aforesaid factors, the vat is put up in a pit of 3 ft x 3 ft x 3 ft dimension in a open space. The space should not have air / wind direction towards the surface of the vat. If so, the direction of the flow of air needs to be regulated as the indigo vat is in open space. The wind direction, sunlight and heat could cause lot of fluctuations in the temperature, pH and the oxygen in the ambient air which delays or halts the fermentation reduction of the indigo in the vat.

Temperature

Temperature of the fermentation vat is one of the vital factors that govern both fermentation and dyeing process in dyeing with the Indigo. The temperature of the vat should remain similar to that of human body temperature that is the temperature could vary between 33^0 C and 37^0 C.

The less the temp, the difficult it is for the natural bacterial enzymes to break the stable water insoluble indigo structure to water soluble indigotin particle that dyes the natural fibres.
The main heat sources for the vat are:

1. The mixture of goat dung and cow dung, which constantly emits heat and maintains the heat.
2. The solar energy and the atmospheric temperature, that gets transmitted through the earth and the mixture of cow and goat dung.
3. The inputs to the vat such as the sugar content material, the alkaline material that is the caustic lime (Calcium carbonate)/ slack lime(calcium hydroxide), c in this case, and the seeds of Casia tora plant.
4. The heat generated through the interaction between the sugar content, alkaline material and the bacterial formation and fermentation.

There needs to be a balance in the kind of heat that is transmitted from outside the vat and the heat that is generated in the vat. The vat is used for dyeing only when the dye-bath is still. Stirring while dyeing in vat is not recommended as there would be lot of undissolved dye and lots of other aforesaid salts that would form a kind of layer that would affect the quality of color got from the vat and also the fastness of the color on the fabric, besides uneven dyeing.

Conclusion

Traditional practice of Indigo dyeing has always been responsible and sustainable practice on both small and medium scale of operation, though not responsible at large scale. Natural vat uses water and other ingredients as required rather than bulk use. It is one of the most responsible dyeing practices in the whole world, when practiced in the most traditional manner. It is important to disseminate the knowledge and create awareness. It has been a great learning experience to have interest, study and understand an Indigo vat. It behaves in many ways like a living being, that it could express itself. If it is ready for dyeing, if it needs something, it expresses in many ways than one. In this paper, an effort has been made to put in scientific views and understanding only, although there are many facets of Indigo vat including its esoteric, mystic associations especially with regards to women, which are not discussed here.

Reference

1. Bagul, Dinesh. *Dyeing Techniques of Ajrakh & Malir: A Document in Ajrakh & Malir Craft of Barmer District, Rajastha*n. NID Craft Documentation R 0108. Ahmedabad: NID, 1993.
2. Gittenger Mattie. *Master Dyers to the World.* Washington DC: Textile Museum, 1982.
3. Humayun, Q M, ed. *Inter Regional Workshop on Natural Dyes.* Lucknow: National Handloom Development Corporation, 1993.
4. Khanna, Nalini. *Deesa Block Printing.* NID Diploma Project D 048. Ahmedabad: NID, 1980.
5. Mohan, Remya. *Shades of Blue: Collaborating with Weavers in Andhra Pradesh.* NID Diploma Project D 1393. Ahmedabad: NID, 2007.
6. Mohanty, B C**,** K V Chandramouli and H D Naik. *Natural Dyeing Processes of India*. Ahmedabad: Calico Museum of Textiles, Sarabhai Foundation, 1987
7. Mohanty, Nitesh, Ashwini Vaidya. *Natural Dyes through Toofan Rafai.* NID Craft Documentation R 0188. Ahmedabad: NID, 1999.
8. Pathak, Divya. *The Making of Ajrakh in Dhamadka.* NID Craft Documentation R 0181. Ahmedabad: NID, 1996.
9. Ramaswamy, Vijaya. *Textiles and Weavers in Medieval South India.* New Delhi: Oxford University Press, 1985.
10. Sahoo, Shalini. *Earth to Earth.* NID Diploma Project D 1106. Ahmedabad: NID, 2005.
11. Shah, Angana. *Dabu (Mud} Printing in Ahmedabad and Deesa.* NID Craft Documentation, R 0007. Ahmedabad: NID, 1980.
12. Singh, Gunjan. *Thulma and Chutka: Rediscovering the Tradition of Shauka Textiles.* NID Diploma Project D 1400. Ahmedabad: NID, 2007.
13. Singh, Smita. *Fleur de Neel: An Experiment with Natural Indigo.* NID Diploma Project D 1330. Ahmedabad: NID, 2006.
14. Singh, Vasundhara. *Mohar: A Tale of Natural Dyes and Block Prints in Rajasthan.* NID Diploma Project D 1430. Ahmedabad: NID, 2007.
15. Tolat, Padmini. *Natural Indigo and Its Use*, (Vol. 1-5). NID Diploma Project D 099. Ahmedabad: NID, 1980.
16. Varadarajan, Lotika. *South Indian Traditions of Kalamkari.* Ahmedabad: National Institute of Design, 1982.

Acknowledgement

Compilation of this paper has been possible by interactions with numerous craftspersons viz., Mr Yellappa of Uravakonda, Mr Abdul Jabbar Khatri of Damadka, Dr Ismail Khatri of Ajrakhpur. The author would like to dedicate this article to those craftsmen, who have been practicing Indigo dyeing in their own ways independently.

Use of natural colours in *Patachitras* by the *Potua* —— a pilot study in the district of Midnapur, West Bengal.

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Abstract

In the domain of art, crafts and paintings an indigenous type of rural paintings is found which is specially made by a section of the rural people known as '*Potua*'. For making these paintings, locally known as "*Patachitras*", the artisans of this group follow the theme of the old stories, ancient rituals, the epics, contemporary issues etc. and exhibit them through their artwork. '*Patachitras*', a means of livelihood for the '*Potuas*' as well as a means of amusement for the rural mass, not only have an aesthetic significance but also have some inner relevance with reference to modern art and paintings. These indigenous paintings have also some remarkable effects to improve the ambience of their dwelling houses and huts. Generally in "*Patachitras*", natural colours are used on porous papers and cloths. This paper reports the observation of a pilot study that has been conducted by the authors in the area of Pingla, Midnapur District, West Bengal with a view to gathering an in-depth knowledge about the nature and the extent of use of natural colours in '*Patachitras*' by the '*Potua*' of that locality. Authors' observation has been elucidated in this paper in the light of modern art and paintings, with special reference to indigenous paintings of our country.

Introduction

Since time immemorial indigenous system of art and crafts came into existence. In the domain of Art, crafts and painting we find a typical type of rural paintings, specially made by a section of people generally called "*Potua*". The paintings received the nomenclature as "*Patachitra*". For making "*Patachitra*" the artisans of this group follow the old stories, ancient rituals, the stories of epics, contemporary issues, and these themes are exhibited through their "*Patachitra*". In the kingdom of art and paintings this "*Patachitra*" has a very social significance. "*Potua*" not only maintains their livelihood through "*Patachitra*" but the paintings have also an inner significance, with reference to modern art and paintings.

"*Patachitra*" has a very historical significance in our country. The artisans of "*Pata*" generally prefer to use various colours for their paintings which are produced from local and indigenous resources. A pilot study was conducted with a view to gathering an in-depth knowledge about the nature and the extent of use of natural colours in '*Patachitra*s' by the '*Potua*' of that locality and the stories / theme they accept to prepare their *Pata*. The study was conducted in the area of Pingla of Midnapur district in West Bengal. The study was conducted with an expectation that it will open up a new vista in the domain of art and paintings.

Historically, the area of Pingla is situated very near to the ancient port of Tamralipto. Tamrolipto port was famous for export and import of cloths and cotton textiles and other important articles in different places of India and abroad. Further to be noted that it is also near to modern ports, like Haldia of Midnapur district and Khidirpur of Kolkata. As the "Potuas", the artisans of "*Patachitra*" are living close to such area where the trading is done in a good surrounding zone, therefore it may be expected from them to be aware of the nature of the dyes used for printing, the process of dyeing of the textile items and the colouring pigments that they use in "*Patachitra*". It is evinced from their "*Pata*" that they are very much aware of the current affairs also. As an example, the contemporary "*Patachitra*" may be taken for consideration, which depicts Laden, the abolishment of World Trade Centre in U.S.A etc.

In painting of "*Pata*", the artisans generally use the colouring pigments which are readily available in the locality. The ideas of using colouring pigments on "*Pata*" are spread out in this locality for painting with different known colouring pigments which are derived from the natural resources. During the passage of time these have been developed. Specially, a group of people are observed in this locality, who are interested and have engaged themselves to prepare the "*Pata*". They are known as "*Patachitra*kar". They use folk songs, folk stories and the stories of our epics etc. The "*Patachitra*" has been accepted as the artistic work in the early 20^{th} centuries.

The people of Pingla region, irrespective of their religions, prepare the "*Pata*' by using the stories of Hindu God and Goddess, figures of different birds and animals etc. They prepare two different types of "*Pata*" namely, "*Santhali Pata*" and "*Bengali Pata*". In case of "Santhali *Pata*", the painting of eyes is most important according to the artisans of "*Pata*".

The subjects of "*Bengali Patachitra*" are completely different from that of "Santhali *Patachitra*". It has been observed that the "*Bengali Patachitra*", in which the stories of different God and Goddess, ancient characters, stories of epics, recent facts etc. are the main issues, generally highlights the stories or facts by a series of painting which are sequence arranged.

In addition to those topics the marriage of fish, birds, animals etc. are also used for painting on "*Pata*". These "*Patachitra*s" are very popular among the rural as well as the urban people.

In "*Patachitra*", the "*Potuas*" use the natural colouring pigments which are in limited hues, e.g. black, red, red-jafran, blue, white, green, yellow, and brown. The colours are very important in "*Patachitra*" to highlight different figures, different stories, different compositions, and natural sceneries, and use of colours make them prominent. The processes of painting follow a very naturalistic, artistic, creative and systematic activity. Generally, it may be stated as a very scientific work in the field of painting. Artisan highlights his idea on the art-paper step by step with the help of natural colouring pigments. Prior to the painting, the extraction of the colouring pigments from various sources is done very carefully. The preparation of gum is also to be noticed, and where it is added to the colouring pigments duly extracted from the source for maintaining the required viscosity of the coloured paste for paintings is a matter of concern. In this case, mixing of the both is done as per the desired tonal value of the respective colours to be put. This way they prepare a series of paintings on the selected topic. After preparing these paintings, they paste the paintings serially on the cloth by using gum which they prepare from the seed of tartaric. The preparation of natural colouring pigments is itself a traditional craft which does not involve a lot of money. However, the colour remains intact for a long time without fading.

The training for making "*Patachitra*" does not require any traditional/formal education. It requires sufficient training from the "Guru", instead. The presentation of "*Patachitra*" follows a very systematic skill. The presenter of "*Pata*" sings the related song during the presentation of the paintings before the audience. The writing of song also requires creative ability of the artisan. To link up the painting with the song essentially requires the skill of the artisan. Like "*Patachitra*", the songs of "*Pata*" have also been accepted as the folk songs in our country. The "Patachitra" and the accompanied songs serve one of means of amusement/entertainment for the common mass and rural people, in particular.

Preparation of different colours used in "*Patachitra*"

The processes of preparation of different coloures that are used in "Patachitra" are as follows:

White

A special type of clay, called "Kusum Moti" or the soft white stones are collected and then either crushed to get the powder and then added with requisite quantity of water or rubbed onto a surface with water to get the paste, then dried in sunlight. After that the gum is added to make it ready for painting.

Black

Soot mixed with gum is used as the black colour for the painting. Soot is collected from oil lamp, charcoal, burnt rice grains etc.

Red

The teak leaves are collected then crushed and squeezed to get the colouring solution which may be dried in the sunlight. When the gum is added in it, it becomes ready to be applied for the paintings. The seeds of the saffron are also used for the red-jafran colour. In this case the seeds are first removed from the fruit pods and rubbed by hands. Thus the colours are collected and kept in a container and dried in the sun, and then glue is added to make it ready for painting.

Green

The leaves of "*Kundri*" are collected and crushed by a pestle and then the pigments are collected and dried in the sun. Finally, the glue is added. The leaves of the Runner-beans, Flat-beans, Bottle-beans, Indian beans are also taken for the green colour.

Brown

The matured leaves of the teak are collected in such a manner that the stalks are removed before and then crushed by a pestle. Finally, requisite quantity of glue is added.

Blue

The flowers of Butterfly pea are either used directly by rubbing on the scroll for blue or the flowers are crushed and added with the glue.

Yellow

The roots of turmeric are used for getting yellow colour. The roots are crushed and squeezed and dried in the sun and then glue is added. The duration of drying or exposure to the sunlight gives different tonal variation of the yellow.

Gum preparation

The gum is generally prepared from the seeds of the "*Bael* fruit". The mucus like substance around the seeds and the seed itself are the source of gum. The seeds are crushed and mixed with requisite quantity of mild water to make the gum. The viscosity of the gum is maintained with addition of adequate amount of water. Alternatively, the "Potuas" purchase the powder of the gum from the local market also.

During the survey in the area of Pingla, two significant points have been observed:

1) Most of the artisans of this area are Muslims, but they use the stories of Hindu God and Goddess for their "*Patachitra*" paintings.
2) They not only use art-papers or cloths for their paintings but also they prefer to exhibit their paintings on the walls of their houses.



Observation and conclusion

From the points cited above, it may be mentioned that religion of the artisans does not affect the work of "*Patachitra*", which is very significant to the present day scenario of our country as well as the today's quarreling world. It is a very creative work, which generally reflects the inner urge of the artisans. The "*Patachitra*" carries a very traditional system of art and paintings. Along with the "*Patachitra*", the songs which are compiled by the artisans require a very creative aptitude. One point should be mentioned here that the dye used for the printing of the cloths is not similar to that used for the "*Patachitras*". The "*Patachitrakars*" prepare the natural colouring pigments by themselves from the easily available local ingredients.

Finally, it may be mentioned that although there are different synthetic dyes which have significant application and impact on the paintings on papers and cloths etc, but the "*Patashilpi*" adopts the traditional colours i.e. the natural colouring pigments, till date. The "*Patachitrakars*" are very much conscious about the nature of the synthetic colours and prefer to use the natural colouring pigments which are having some unique character besides their eco-friendliness.

Appendix

Patashilpi/Patachitrakar/Potua; Scroll Painter; ***Patachitras/ Pata:*** Scroll Painting; ***Guru:*** expert artisan; ***Bael:*** Wood apple (Aegle marmelos); ***Kundri:*** Little gourd (Coccinia indica); ***Barbati:*** Cowpea (vigna sinensis); ***Indian bean***: Dolichoslablab; ***Turmeric:*** Curcuma longa; *Jafran:* Saffron (Crocus sativus; ***Teak:*** Tecoma grandis; ***Butterfly pea:*** Clitoria tematea; ***Paddy:*** Oryza sativa.

Application of vegetable dyes in carpet industry

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Abstract

A natural dye not only has its application in the textile industry, but in the fashion and apparel industries also. In this article, a new aspect has been covered by exploring the possibilities of application of vegetable dyes in the domain of carpet industries.

Keywords: Vegetable dyes, Carpet Industry, Pre-treatment, Post-treatment, Washing fastness, Rubbing fastness

Introduction

Nature is full of marvels, many of which are yet to be revealed by the mankind to understand its wonderful phenomena. It imparts various uses in human life apart from the materialistic world that we live in, with all the man-made machines doing all the work, surrounding us with its super abilities to lessen our work. The most vital use of nature in our life is the food that we take in to keep us alive. Food, including vegetables, fruits and all edibles found in nature, as well as the man-made ones manufactured in various industries, also partially originate from the nature itself. So nature has its contribution in some way or the other in everything that happens around us in every moment. Now do the trees, fruits and vegetables from nature only serve the purpose of food in human life? Of course not, and all of us are pretty aware of its multipurpose uses too. For instance, what the clothes that we wear, are made up of? ... Fibres, and where do they come from? They are actually extracted from plants or in some cases, from their fruit, or from animals. Fibres have its use not only in making clothes but also for various others too. For example, ropes, gunny bags, shopping bags, carpets and many more. But does anyone like clothes or any other products without colors on it?.. 'NO'.

Love for color is a natural instinct. Every individual has his own choice and liking for color. Whether it is icy appearance of the Himalayan ranges, or evergreen forests, or lush green agricultural fields, or trees laden with colorful ripe fruits, or the colorful butterfly moving from one flower to another, are centres of attraction over generations. A beautiful color is fascinating for everyone. Some people are simply crazy about colors. If something does not have color, they will simply dye on it, and if it has a color already, they will over dye it. The dying technique being as old as few millennium; all that's new today is the number of different dyes that can be used. Many natural dyes are known for long time. Until the middle of nineteenth century, all dyes available to man came from natural sources. Most of these were natural extracts and few were animal products. The range of colors as well as utility of dyes was limited. Fiber dyes were already used in prehistoric times after the last ice age, around 1000 B.C. They consisted of fugitive stains from berries, blossoms, barks and roots.

They were early examples of so called direct dyes, i.e. dyes that color the fibre without special pretreatment of the dye-material or the textile.

The ability of natural dyes to impart color to textiles has been known since ancient times. The history of natural dyes is very interesting. The earliest authentic record of the use of natural dyes may be traced back to 2600 B.C in China. The fabric found in the tomb of Tutankhamen in Egypt, has been shown to contain Alizarin, a red pigment extracted from madder. More recently, Alexander the great, made use of a red dye (probably madder juice which contains Alizarin dye) which he used to sprinkle over his army to fox his Persian enemies by making them think that his soldiers were wounded. By the 4^{th} century A.D, dyes such as woad, madder, weld, Brazilwood, indigo and dark reddish purple were known.

Natural dyes are a class of colorants extracted from vegetative matter and animal residues. The raw material for the production of natural dyes is mostly vegetable matter such as seeds, leaves, roots, barks or the heartwood of the plants. Some of the plants recommended for the production of natural dyes for dyeing of textile substrates are given below in Table 1.

Natural dyes are produced from different parts of plant e.g. from roots, barks, heartwood, leaves, flowers, gum like secretion from insects, seeds etc. Since plants are grown in different climatic conditions and are not scientifically cultivated, the collection of color bearing components may not be possible at any given time. Apart from this, the moisture content and maturity of collected materials impart variation in extracted color components. For example, over dried bark, flowers, seeds, loose color components due to degradation. The natural color and hue of a dye can be altered by treating with metal salts. If the dye is of plant origin, the color may vary depending on the soil properties, part of the plant, season of harvesting, cultivation practices, etc. Natural dyes lack color fastness to various agencies. 'Mordants' are used to improve color fastness of dyes. Mordants form insoluble compounds with dye within the fibre. They enhance the color pick up and help improve the fastness of dyes considerably. The dyes which have electron donating groups (O-hydroxyl) in their structure are capable of forming a complex with transition metal ions. These dyes are considered under the class of mordant dyes. Mordanting can be carried before or after dyeing, depending upon the requirement.

A natural dye not only has its application in the textile industry, but also in fashion and apparel industries, and to bring a new aspect, it is also exploring the fields of carpet industries. This new area of natural dye application has emerged due to one and only reason i.e. eco-friendliness of the product. Carpets are manufactured in many regions in India which are then exported to the foreign countries. Cities like Jaipur, Panipat, Delhi, Varanasi, Gopigunj, Mirzapur and Bhadohi (popularly known as the Carpet City) are famous for producing carpets in India. Mostly these are woolen carpets. Viscose or Polyester yarns are also used to enhance the aesthetic value of rugs, primarily to attract foreign customers. Exporters from different places are trying various innovative ways and adopting various new techniques to boost business with foreign buyers. Amongst these newly adopted techniques, one is the use of natural dyes for dyeing of woolen yarns in carpets. The heightened awareness about the hazards caused by usage of synthetic dyes and chemicals during the dyeing procedure, people are becoming more conscious about their health as well as their environment. Most of the foreign customers prefer natural dyes over synthetic dyes nowadays, hence this re-emergence of natural dyes in the market. A brief description on the dyeing process and recipes of some shades dyed with natural dyes on wool for carpets are summarized below.

Experimental

General procedures and considerations for dyeing wool with natural dyes

Material

Wool: Wool being protein fibre, contain functional groups for absorbing natural dyes. Carpet wool is generally dyed in hank form.

Chemicals used

All the chemicals used are either of laboratory reagent grade or of commercial grade.

Considerations

- % Shade**:** All shades here are reported as percentage on weight of material (owm). Generally, the amount of dye required is less in case of wool.
- Material to liquor ratio (MLR): Material to liquor ratio for reported dying is maintained at 1:20 for wool.
- All dyes and chemicals should be carefully stirred and dissolved in the dye bath before the wool is added.

Procedures

- Scouring of wool: Wool to be dyed should be pre-scoured with 2gpl of non-ionic detergent at 60^0 C for about one hour.
- Soaping: For getting good wash fastness, after dyeing; all samples should be soaped with non-ionic detergent (0.5 gpl) at 60^0 C for 20 minutes. After this, the samples should be given hot wash followed by cold wash.
- Water: Dyeing with natural dyes should be carried out by using soft water. Hard water containing metal ions such as iron, calcium and magnesium tend to give dull shades.
- pH: The pH of each dye bath should be tested. Natural dyes should be dyed from the same pH every time to get reproducible shades. It is advisable to maintain constant pH during dyeing.

After Care

- Washing during use: As these dyes are sensitive to pH, the dyed wool should be washed with neutral detergents. Washing with common alkaline domestic detergents may result in the change of original shade.
- Drying: Material dyed with Natural Dyes should be dried in shade, preferably in the flat state.

Recipes of some shades dyed with natural wool

Recipes of the dyes mentioned in Table 1 are given below:

1. ***Acacia catechu***

1a. 17-1227TC CAFÉ 'AU LAIT

Dyeing: Dye (1.5%) and Copper Sulphate (0.25%) is added to the dye bath and stirred well to dissolve them properly. Material is then added to the bath and kept for 30 min at a temp. of 80^0 C. It is then followed by soaping as per the directions mentioned above.

1b. 19-061TC TEAK
Dyeing: Dye (8%), ferrous sulphate (2%) and copper sulphate (2%) are added to the dye bath and stirred well for proper dissolution. Material is added to the dye bath and kept at 80^0 C for 30 min. Soaping is done as indicated.

3c. 18-1030TC THRUSH
Pre-treatment: The material is pre-treated in a bath containing alum (10%) and tartaric acid (5%) at 80^0 C for 30 min.
Dyeing: Dye (5%) and copper sulphate (2%) are added to the dye bath followed by well stirring. Material is added to the dye bath and dyeing is continued for 30 min at 80^0 C.
Neutralisation: Material is treated with sodium hydroxide (0.5%) at room temp. for 10 min. and soaping is carried out as per indication.

2. *Mallotus philippinensis*
15-1049TC ARTISAN'S GOLD
Pretreatment: Material is pretreated with alum (8%) at 80^0 C for 30 min.
Dyeing: Dye (6%) is added to the dye bath. Sodium hydroxide is added to maintain the pH to 9. Thorough stirring of the dyes and chemicals are carried out so that they get dissolved properly. Material is then added to the dye bath maintaining the temp. of 80^0 C for 15 min. Acetic acid is added to the dye bath to adjust pH to 5 and dyeing is carried out for another 20 min at 80^0 C. Soaping is done following the above mentioned standard recipe.

3. *Quercus infectoria*
17-1212TC FUNGI
Dyeing: Dye (6%) is added to the dye bath followed by thorough stirring. Material is added to and dyeing is continued for 30 min at 80^0 C.
Post-treatment: Dyed material is treated with ferrous sulphate (0.5%) at room temp. with constant stirring for about 20 min followed by soaping.

4. *Rheum emodi*
15-1142TC HONEY GOLD
Pretreatment: Material is treated with (8%) alum at 80^0 C for 30 min.
Dyeing: Dye bath is made acidic with sulphuric acid 2-3% (pH 2). Dye (4.5%) is added to the dye bath. After the dyes and chemicals are well dissolved, material is added to the dye bath. Dyeing is continued at 80^0 C for 30 min followed by soaping as indicated.

5. *Indigofera tinctoria*
5a. 19-4118TC DARK DENIM
$5a_1$. 19-4028TC ISIGNIA BLUE

Dyeing: A paste of dye (1.5%) with a non-ionic detergent is prepared with required amount of hot water to get a fine dispersion. Sodium hydrosulphite 3-4 times and caustic soda 1-1.5

times is added on the weight of dye, stirred well and kept for 20 min. The color of solution becomes light yellow. If the color does not change more sodium hydrosulphite and caustic soda are added to obtain the pH of 11-12. Material is added to the dye bath and dyed for 20-30 min. It's then taken out, exposed to air, again dipped in the same solution and dyed for another 20-30 min. Sodium hydrosulphite and caustic soda are added constantly to keep the color of bath pale yellow throughout the dyeing process. Finally, the hank is taken out and kept in air till blue color develops. Soaping is done as indicated.

$5a_1$. Dye 3%, procedure as reported above.

Assessment of color fastness to washing

Washing fastness:

Norm : IS 5461:1993, Test Method : IS 3361:1979

Assessment of color fastness to rubbing

Rubbing Fastness:

Norm : IS 5641:1993, Test Method : ISO 105 X 12

Assessment of color fastness to light

Light Fastness:

Norm : IS 5461:1993, Test Method : IS 2454:1985

Results

Table 2 shows data for Fastness properties of Natural Dyed carpet Wool.

Conclusion

India's great tradition of vegetable dyes is unequalled anywhere in the world. However the European development of synthetic dyes in the mid 19^{th} century ended the export market of colorful textiles as well as the dyestuffs. The technical skills of vegetable dyeing were lost to all but a minority of textile craftsmen. However today there is renewed interest in natural dyes due to bans being imposed by European Government, because of health risks from numerous synthetic dyes that they originally developed. The limitations of the natural dyes that were responsible for their decline were availability, color yield, and complexity of dyeing process and reproducibility of shade. The market for natural dyestuffs is very small. As opposed to natural food and natural cosmetics, where outlets are numerous and widespread, naturally dyed clothing (with few exemptions) is not widely available to the average consumer. The technology to utilize natural dyes in the modern clothing industry or even carpet industry is relatively new and still being improved upon. Many textile manufacturers have not yet found any incentive to switch to natural dyes, which are more expensive than synthetic ones. However, off late there has been an increasing interest in natural dyes, as the people have become aware of ecological and environmental problems related to the use of synthetic dyes. Use of natural dyes cuts down significantly on the amount of toxic effluent resulted from the dyeing process.

The following properties are often considered to be the advantages of natural dyes:

- ✓ They are obtained from renewable resources.
- ✓ No health hazards, sometimes they act as health care.
- ✓ Practically no or mild chemical reactions are involved in their preparation.
- ✓ No disposal problems.
- ✓ They are unsophisticated and harmonized with nature.

Hence, we can conclude that the use of natural dyes in carpet industries especially in woolen carpets make the product completely natural without causing any kind of environment pollution. As a result, this makes the final product more marketable and at the same time more attractive with its enhanced beauty before the foreign customers.

References

1. Convention proceedings Natural dyes 17-18th December, 2001, edited by Deepti Gupta and M.L. Gulrajani, (IIT, Delhi).
2. Dyeing of Carpet, Wool and Silk With Natural Dyes (IIT, Delhi and IICT, Bhadohi)
3. http://www.icr.com.au
4. http://www.botanical.com
5. http://www.raise.org/natural/pubs/dyes/annex.stm
6. http://www.tifac.org.in/do/hgt/case/nat_dye.htm
7. Ch Giles, DP Johari and CD Shah, TRJ, 38(1968) 1048
8. M.L. Gulrajani, IJFTR,26,(2001) 191-201
9. W. Cummings et al., JSDC, 72 (1956) 373
10. PC Crews, J. AM. INST. Conserve., 21 (1982) 43

Table 1: Raw materials used for the production of natural dyes

Sl No.	Botanical Name	Common Name	Part of the Plant
1.	*Acacia catechu*	Cutch	Heartwood
2.	*Mallotus philippinensis*	Kamala	Flower deposits
3.	*Quercus infectoria*	Gall nuts	Fruit
4.	*Rheum emodi*	Himalayan rhubarb	Roots
5.	*Indigofera tinctoria*	Indigo	Leaves

Table 2: Data for fastness properties of natural dyed carpet wool

Sl.no.	Procedure Number	Dye %	Light Fastness		Rubbing Fastness			Washing Fastness		
			Fading	Color Change	Wet	Dry	Color of stain	C C	C B	Color Change
1.	1(a)	Acacia catechu 1.5%	3	light	4-5	4-5	same	4	5	—
2.	1(b)	Acacia catechu 8%	4-5	light	3-4	3-4	same	5	5	—
3.	1(c)	Acacia catechu 5%	3	yellow	3-4	4	same	4	5	redder
4.	2	Mallotus philippinensis 6%	1	light	3	3	same	4	4-5	—
5.	3	Quercus infectoria 6%	2-3	yellow	4-5	4-5	same	3-4	4-5	black
6.	4	Rheum emodi 4.5%	2-3	dull	4	4	same	4-5	4	dull
7.	(5a)	Indigofera tinctoria 1.5%	6<	—	3-4	4	same	5	5	—
8.	($5a_1$)	Indigofera tinctoria 3%	6<	—	3-4	3-4	same	5	4-5	—
CC: Colour Change, CB: Colour Staining on wool.										

Application of natural dye for colouration of jute and cotton textiles

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Abstract

Today's consumers understand the value for money and therefore, organic non-toxic products in every field have created a new icon. So, textiles using of eco-friendly natural dyes on natural fibres is a present trend in its field. Natural dyes application on textiles is acknowledged since ancient past. However, recent awareness of organic concern has led revival of this bio-resource technology of widely available natural colourant from different sources for different types of textiles preferably for natural fibre products. Jute and cotton are not exclusion in this endeavour. Hence, in recent past, series of R&D work is under process for last 5-10 years to standardize different colours/shade development with natural colourants, with eco-safe mordants and chemicals for obtaining uncommon, soothing and acceptable colours/shades on jute and cotton fabrics. Department of Jute and Fibre Technology, erstwhile, Institute of Jute Technology (IJT), being premier Institute on jute and allied fibres is working for more than 8-10 years on such endeavour. The present paper depicts the process of extraction, purification, characterization of different natural dyes and standardization of the methods of mordanting, dyeing and colour fastness using eco-friendly/biotechnological processes for application of selective natural dyes (aqueous extract of Jackfruit wood, Red sandal wood, *Tesu*, Manjistha etc), for developing variety of standardized shades for exportable jute fabrics. It is observed that sequential double mordanting by application of 10-20% *myrobolan* followed by 10-20% of $Al_2(SO_4)_3$ is identified as the most prospective mordanting systems. Most of the selective natural dyes applied on jute follow Nernst isotherm i.e., less or no coordinated complex formation in dye – mordant – fibre system, rather it follows mere hydrogen bonding or other weak interactions except a few cases. The integrated study for the above said aspects for application of natural dyes has opened up a new marker segment for natural dyes eco-friendly jute products.

***Keywords*:** Dyeing, Jute, Mordanting, Myrobolan, Natural dyes, Tesu

Introduction

Most of the natural dyes are proved to be non-toxic and eco-friendly with some exceptions [1]. Furthermore, both cotton and jute are agro-renewable and biodegradable natural fibres. However, the main technical problems of natural dyed cotton and diversified jute products lie with the difficulty to achieve the levelness of shade, acceptable colour fastness and endurance properties. As a result, the products fetch lower value and it affects consumers' acceptance. These technical defects are to be eliminated or need be resolved for successful development of the business and acceptance of the products by customers.

Jute differs from cotton both physically and chemically in chemical composition. Consequently, dyeing properties and action of various chemicals on jute used in pretreatments or as dye-bath assistance are somewhat different from that of cotton. Hence, for dyeing of jute and cotton textiles even with the same natural dye need separate study, to optimise dyeing process variables and colour fastness properties and other colour parameters. However, as synthetic dyes and natural dyes differ in many respects, it needs to have short information on the science of natural dyes along with a brief review on the scientific R&D work so far done on these aspects.

Being coarser, jute is mainly used for low priced bulk packaging, i.e., sacking. But, now-a-days, it is also being used as wall decorative and furnishing fabrics besides many other diversified jute products including home textiles [2] and geotextiles etc. Jute is chemically composed of cellulose, hemi-cellulose and lignin as major constituents and accepts wide range/classes of dyes [3]. Hence, unlike cotton, the dyeing characteristics of jute for any natural dyes are different owing to the differences in its chemical composition, chemical functionality pattern and differences in fine as well as gross structure from cotton.

Despite the common disadvantages for application of natural dyes on textiles such as practical difficulty in its two stage application (mordanting and then dyeing usually), reproducibility, non-uniformity of shades and poor to moderate colour fastness etc., special technical advantages for application of natural dye are its un-common and soothing shades, agro-renewable nature of vegetable/natural dyes and its eco-friendliness [4-6]. However, except few discrete reports, there is lack of detailed scientific information on exact chemistry of colour component of natural dyes, physical chemistry of dyeing, standardized dyeing process conditions and optimised dye extraction method for different natural dyes. Moreover, insufficient scientific information and knowledge possess further challenge to the textile chemists and dyers [5-8] to achieve uniform and optimum colour yield. The availability of required scientific information and reports in literature for dyeing of silk and wool fibres with natural dyes are much abundant, but the same for jute and cotton is rather scanty and sporadic [9, 10].

With this milieu, it is thought appropriate to study the effects of selective single and double mordants on textile related mechanical properties, effects of dyeing process variable on colour yield, colour fastness properties of jute and cotton fabrics using aqueous extract of natural colours/dyes.

Materials and Methods

Materials

Jute and Cotton Fabrics

Table 1 furnished below shows the specifications of conventional bleached jute and cotton fabrics with used in this study:

Table 1: Specification of fabrics used

Parameters	Jute	Cotton
Ends/dm x Picks/dm	67 x 67	220 x 180
Warp count, tex	176	15
Weft count, tex	164	19
Area density, (g/m^2)	225	120
Thickness , mm	0.70	0.28

Laboratory reagents (LR) grade aluminium sulphate, potasium aluminium sulphate, ferrous sulphate, stannous chloride, EDTA and commercial grade acetic acid, common salt, sodium carbonate, sodium hydroxide, and non-ionic soap obtained from local suppliers were used. A natural mordanting assistant myrobolan (harda, botanically known as *Terminalia chebula*) powder was also used as one of the eco-friendly mordant (mordant assistant or secondary mordant) for present study. As eco-friendly natural dyes, tesu (palash flower petals), manjistha (root, Indian madder) and jack fruit wood were used for present study.

Methods

Extraction of Colour Component

For optimizing the extraction method, the aqueous extraction of dye liquor was carried out under varying condition, such as time of extraction, temperature of extraction bath, *p*H of extraction liquor, concentration of colour-source material (Jackfruit wood, *Tesu*, *Manjistha*) and material-to-liquor ratio. In each case, the optical density or absorbance value at a particular maximum absorbance wavelength for the aqueous extract of the jackfruit wood was estimated using Hitachi-U-2000 UV-VIS absorbance spectrophotometer.

Various conditions used for the aqueous extraction of colour component from source of natural dyes (jackfruit wood, *tesu*, *manjistha*) and the respective absorbance values are given in Table 2.

Table 2: Various conditions and absorbance of aqueous extraction of various colour components

Extraction variable	Absorbance of colour component at λ $_{628\ nm}$ for Jackfruit Wood Extraction	Absorbance of colour component at λ $_{490\ nm}$ for *Tesu* Extraction	Absorbance of colour component at λ $_{471\ nm}$ for Manjistha Extraction
Time, min 5	2.50	-	-
10	2.62	-	-
15	2.71	2.426	2.212
30	**2.77**	2.457	2.225
45	-	2.458	2.238
60	2.68	**2.462**	**2.247**
75	-	2.460	2.235
90	-	2.427	2.205
120	2.60	2.213	1.256
Temperature, ^{o}C			
30	0.72	2.345	1.574
45	-	2.356	1.892
60	1.55	2.391	2.168
75	-	2.434	2.187
90	2.63	**2.462**	**2.247**
100	**2.77**	2.358	2.046
Material-to-liquor ratio			
1:2.5	2.66	-	-
1:5	2.69	2.435	2.043
1:10	**2.77**	2.443	2.120
1:15	2.54	2.453	2.151
1:20	2.23	**2.462**	**2.247**
1:25		2.460	2.239
1:30		2.457	2.237
1:40		2.431	2.202
*p*H			
4.0	1.49	1.918	1.567
5.0	1.60	-	-
6.0	1.99	2.016	1.572
7.0	-	2.319	2.103
8.0	2.01	2.324	2.169
9.0	-	2.339	2.075
10.0	2.69	2.422	2.188
11.0	**2.77**	**2.462**	**2.247**
12.0	2.73	2.220	2.168

*The bold values indicate the optimum conditions for the extraction of colour component from respective natural dye.

First mordanting of jute and cotton fabrics with Myrobolan

The *myrobolan* (*harda*) powder was soaked in water (1:10 volume) for overnight (12h) at room temperature to obtain the swelled *myrobolan* gel. This gel was then mixed with a known volume of water and heated at 80ºC for 30 min. The solution was then cooled and filtered in a 60 mesh nylon cloth and the filtrate was used as final mordant solution (10-40%) for mordanting, using MLR of 1:20. Pre-wetted conventional H_2O_2 bleached jute and cotton fabrics were separately treated with the *harda* solution in separate bath initially at 40-50ºC and then the temperature was raised to 80ºC. The mordanting was continued for 30 min. After the *harda* mordanting, fabric samples were dried in air without washing to make them ready for either subsequent dyeing or for second mordanting.

First/second mordanting of jute and cotton fabrics with metallic salts

Conventionally bleached (H_2O_2) jute and cotton fabrics with or without initial 1st mordanting were further mordanted prior to dyeing using 10-40% of any one of the chemical mordants, (such as aluminium sulphate, aluminium potassium sulphate, ferrous sulphate, stannous chloride and EDTA) at 80^{o}C for 30 min using material-to-liquor ratio of 1:20. After the mordanting, the fabric samples were finally dried in air without washing to make them ready for subsequent dyeing.

Dyeing of pre-mordanted jute and cotton fabrics

Bleached and or differently mordanted (single or double) jute and cotton fabrics were dyed using the aqueous colouring extract of jackfruit wood under specific and/or varying condition of dyeing. For general study of dyeing behaviour using different mordants, a prefixed normal dyeing condition (aq. extract of jackfruit wood), 20%; mordant, 20%; MLR, 1:20; common salt, 10gpl; *p*H 11.0 (with requisite amount of NaOH); dyeing temperature, 100ºC and dyeing time, 60 min) was used. However, for *tesu* and *manjistha* dyeing temperature was 90ºC and dye concentration was 50%, keeping other normal dyeing conditions same.

For studying the effect of dyeing process variables on colour yield to optimize the dyeing conditions, the dyeing conditions were varied as follows: dyeing time 45-120 min; dyeing temperature 60-100°C, material-to-liquor ratio 1:10 - 1:50, concentration of mordants 10-50% (myrobolan) and 20-40% (other chemical mordants), concentration of natural dye (aq. extract), 10-50%,common salt concentration 5-20gpl and *p*H 4 -12.0. The selective mordant systems used for the study of dyeing process variables are: (i) double pre-mordanting with 20% harda (1st mordant) followed by 20 % aluminium sulphate (2nd mordant) applied in sequence on jute (A) and/or on cotton (A′) (ii) double pre-mordanting with 20% harda (1st mordant) followed by 20 % ferrous sulphate (2nd mordant) applied in sequence on jute (B) and on cotton (B′), except in the cases of study on variation in mordant concentrations (10-40%) .

In each case, after the dyeing is over, the dyed samples were repeatedly washed with hot and cold water and then finally, the dyed samples were subjected to soaping with 2gpl soap solution at 60 °C for 15 min, followed by repeated water wash and line dried.

Determination of *K/S* Value and Brightness Index

The *K/S* value (surface colour strength) of the undyed and dyed jute and cotton fabrics was determined by measuring surface reflectance of the samples using a computer-aided Macbeth 2020 plus reflectance spectrophotometer, using the following Kubelka Munk equation [14] with the help of relevant software:

$$K/S = \frac{(1 - R_{\lambda max})^2}{2R_{\lambda max}} = \alpha\, C_d$$

Where, K is the coefficient of absorption, S, the coefficient of scattering; C_d, the concentration of the dye; and $R_{\lambda max}$, the surface reflectance value of the sample at a particular wavelength, where maximum absorption occurs for a particular dye/colour component.

Brightness index was calculated as per the standard (ISO-2470-1977) method [15] using the following relationships after measuring the reflectance value of the corresponding sample by the same computer-aided Macbeth 2020 plus reflectance spectrophotometer:

$$\textbf{Brightness index} = \frac{\text{Reflectance value of substrate at 457nm}}{\text{Reflectance value of standard white}} \times 100$$

Evaluation of colour fastness

Colour fastness to washing [16] of the dyed fabric samples was determined as per IS: 764-1984 method using a Sasmira launder-O-meter following IS-3 wash fastness method. The wash fastness rating was assessed using grey scale as per ISO-05-AO2 (loss of shade depth) and ISO–105-AO3 (extent of staining) and the same was cross-checked by measuring the loss of depth of colour and staining using Macbeth 2020 plus computer aided colour measurement system attached with relevant software. Colour fastness to rubbing (dry and wet) [16] was assessed as per IS: 766-1984 method using a manually operated crockmeter and grey scale as per ISO-105-AO3 (extent of staining). Colour fastness to exposure to light [16] was determined as per IS: 2454-1984 method. The half of the samples (10cm x 1cm) was exposed to UV light in a Shirley MBTF Microsal fade-O-meter (having 500 watt Philips mercury bulb tungsten filament lamp simulating day light) along with the eight blue wool standards (BS 1006: BOI: 1978). The fading of each sample was observed against the fading of blue wool standards (1–8).

Results and Discussion

Jack fruit wood

Effect of Single and Double Mordanting on Jute and Cotton Fabrics

Bleached jute and cotton fabrics differently mordanted with varying concentration of mordants have been subsequently dyed with varying concentration of extracted dye liquor (JFW), following a prefixed normal dyeing conditions as reported in section *2.2.4*. All the dyed fabrics have been assessed for their surface colour strength (*K/S* value), brightness index, total colour difference (ΔE) and colour fastness behaviour to washing, rubbing and exposure to light and the results are given in Table 3 for single and Table 4 for double mordanted jute and cotton fabrics. It is observed that among differently mordanted bleached jute subsequently dyed with 20% aqueous extract of jackfruit wood, the sequential double mordanting with 20% *myrobolan* and 20% ferrous sulphate renders the fabric relatively higher *K/S* value (~ 12.21) as compared to other mordanting system at comparable dose level. The use of 20% *harda* and 20% aluminium sulphate mordanting technique followed by further dyeing with comparable dose of jackfruit wood colour (20% JFW) shows, the *K/S* value at 3.35 (Table 2) and thus is considered as next good performer. In all the cases of dyeing with different percentages of aqueous extract of jackfruit wood using different mordants, the brightness index values are found to be reduced to a noticeable extent from the corresponding value obtained after respective mordanting. When the jute fabric is double mordanted with *myrobolan* and ferrous sulphate in sequence, the brightness index decreases with the increase in *K/S* value. Hence, considering the dyeing results, the sequential mordanting systems using 20% *myrobolan* + 20% aluminium sulphate and 20% *myrobolan* + 20% ferrous sulphate are found to be more prospective, rendering a higher degree of increase in surface colour strength. These two systems of mordanting have therefore been chosen for further study of dyeing process variables for both jute and cotton fabrics. However, the use of ferrous sulphate in any case always renders both jute and cotton fabrics a deep brownish/grey colour owing to the inherent colour of this transition metal salt anchored to the corresponding fibres, besides the improvement in *K/S* value due to the natural dye component.

Effect of Dyeing Process Variables for Optimizing the Dyeing Conditions

Fig. 1 shows the effect of dyeing process variables, such as dyeing time, dyeing temperature, material-to-liquor ratio, *p*H (concentration of acid/alkali added), mordants concentration, dye concentration and common salt concentration respectively, on the surface colour strength (*K/S* values) of bleached and dyed jute and cotton fabrics after mordanting. The selective fibre-mordanting systems used for the study of dyeing process variables are shown in section *2.2.4*.

Fig.1a shows that keeping all other variables prefixed and unaltered, with the increase in time of dyeing from 15 min to 120 mins, the *K/S* value slowly increases upto 90 min and then either levels off or slowly decreases for all the combinations of fibre-mordanting systems (A) ,(B), (A′) and (B′). Among these mordanting systems, the increase in surface colour strength is much higher for fibre- mordanting system (B) For other fibre-mordanting systems (A), (A′), and (B′), the effect of increase in dyeing time is much subdued; the optimum dyeing time is found to be 90 min. Rate of dyeing for fibre-mordanting system (B) is, however, found to be sharp for 60-90 min period of dyeing. This higher rate of dyeing above 60 min and up to 90 min in case of fibre-mordanting system (B) may be due to the possible reduction in activation energy required for absorption and fixation of dyes on fibre surface by jute-hemicellu-COO^-…Fe-ion complex formation, which is not possible in cotton.

Keeping other dyeing variables constant, with the increase in dyeing temperature from 50^{o}C to 100^{o}C, (Fig.1b), the surface colour strength increases measurably up to 80^{o}C for double fibre-mordanting systems (B) and (B′) and then almost levels off. However, the rate of dyeing and the rate of increase in *K/S* value are found to be much higher for fibre-mordanting system (B) than for fibre-mordanting system (B′). In case of fibre-mordanting system (A) and (A′), the *K/S* value increases slowly at the temperature range 50^o – 70^{o}C and then drop down. The increase in time or temperature of dyeing inevitably supplies more energy, usually facilitating higher rate of dye sorption for all the fibre-mordanting systems, in general, up to a certain limit of dyeing temperature, before desorption starts. However, in case of application of ferrous sulphate as 2nd mordant on jute substrate, the effect is much predominant and higher than those obtained by other mordanting systems applied on both jute and cotton substrates, due to the possible jute-hemicellu-COO^-….Fe-ion complexing in case of fibre-mordanting system (B).

For the variation in material-to-liquor ratio (MLR) from 1:10 to 1:50 (Figure.1c), initially the *K/S* value sharply increases upto MLR of 1:30 and then gradually drops down with the further increase in MLR for both the fibre-mordanting systems (B) and (B′); while the effect is much subdued and marginal in cases of fibre-mordanting systems (A) and (A′). However, for all these fibre-mordants systems, the optimum MLR is found to be 1:30.

Fig. 1d interestingly shows varying degree of crests and troughs in the trends of *K/S* value with the variation in pH values between 3 and 12. However, for fibre-mordanting system (B) on jute sample, relatively two broader crests and one trough are observed, showing higher *K/S* value at *p*H, 5.0 and 11.0; among the two *p*H values, the highest *K/S* value being obtained at *p*H, 11.0. For other fibre-mordanting systems (A), (A′), and (B′), the *K/S* values are found to be much lower than that obtained for fibre-mordanting system (B). But all these three fibre-mordanting systems, except (B) show corresponding maximum *K/S* values either at *p*H 4.0 or at *p*H 11.0 which are also much closer. However, considering the surface colour strength as well as colour fastness behaviour (Table 5) together, *p*H 11.0 may be taken as optimum for all the fibre-mordanting systems studied, as the colour fastness properties are found to be relatively better at *p*H 11.0 than that at *p*H 4.0-5.0.

Fig. 1e shows a slow increase in *K/S* value with the increase in mordant concentration upto 20% before showing the leveling off trend for fibre-mordanting systems (A) and (A′); while there is an increase in *K/S* value with the increase in mordant concentration up to 30% for fibre-mordanting system (B′) before leveling off. The increase in *K/S* value is much sharper and predominant in case of fibre-mordanting system (B) up to 30% mordant concentration, above which it marginally drops down. Thus, for all the fibre-mordanting systems studied, the optimum mordant concentration may be considered to be around 20-30%. However, there is noticeable loss in tensile strength after mordanting bleached jute and cotton fabrics with more than 20% mordants. Hence, the use of more than 20% mordant concentration for mordant systems (A), (A′) and (B′) is not recommended. But despite some strength loss, the use of 30% mordant concentration may be allowed for obtaining much higher *K/S* value for fibre-mordanting system (B), as the increase in *K/S* value for this double mordanted jute fabric is found to be exceptionally higher. So, for fibre-mordanting system (B), the optimum concentration of mordant should be within 20-30%.

Fig.1f shows slow increase in *K/S* values with the increase in concentration of extracted dye liquor up to 30% (on the basis of % solid jackfruit wood), above which it almost levels off reaching almost the saturation level. However, the *K/S* value obtained is always found to be much higher for fibre-mordanting system (B) than that for other fibre-mordanting systems (A), (A′) and (B′). The higher dye uptake in case of fibre-mordanting system (B) indicates and confirms that there is more attraction/substantivity of colour component of jackfruit wood towards such mordanted jute, causing jute-hemicellu-COO^-….Fe-ion complex formation.

Fig.1g indicates that the optimum concentration of common salt for all the four fibre-mordanting systems is 15gpl, as the *K/S* values are found to be maximum at this concentration. However, the observed much lower *K/S* value in the cases of fibre-mordanting systems (A) and (A′) on both bleached jute and cotton substrates is due to the suppression of the action of *harda* by blocking its functional coordinating groups by aluminium metal ion [$Al_2(SO_4)_3$] to a certain degree. The observed highest *K/S* value in case of fibre-mordanting system (B) on bleached jute substrate, indicating the synergistic intensification of colour yield, is assumed to be due to higher absorption and fixation of the dye by the complex formed between the Fe-salts and the $–COO^-$ group of jute hemicellulose, which is not possible in cotton due to the absence of $–COO^-$ group. The observed slow increase in *K/S* value in cotton treated with same mordants is only due to the additive colour yield for the additional incorporation of the inherent colour of $FeSO_4$ itself . The addition of an electrolyte (common salt) to the dyeing liquor in the dyebath in case of dyeing with a mordantable anionic dye like jackfruit wood extract expectedly increases the exhaustion of the dye on the cellulosic or ligno-cellulosic fibres. They dissociate completely in the aqueous dye liquor at different temperatures of dyeing and increase the force of repulsion between the dyes molecules and the water so that the dye molecules are more attracted to the cellulosic or ligno-cellulosic fibres. But higher amount of salt /electrolyte above a certain limit causes retardation effect in the dye adsorption.

Tesu and Manjistha

Effect of Dyeing Process Variables for Optimizing the Dyeing Conditions

Relevant data given in Table 5 indirectly or directly show the effects of the dyeing process variable such as dyeing time, dyeing temperature, material to liquor ratio, pH (concentration/alkali added), concentration of mordants, concentrations of dye extracted from natural dye (on the basis of % of *Tesu* powder or *manjistha*) and concentrations of common salt respectively on the surface colour strength (K/S values) for dyeing of bleached fabrics with *Tesu* and *manjistha* after double mordanting (20% *harda* followed by 20% aluminium sulphate).

Relevant data given in Table 5 indicates that all other variables remaining prefixed and unaltered with increase in time of dyeing (45 – 120mins), K/S value (surface colour strength) slowly increases upto 60 min and then slowly decreases for both the natural dyes *tesu* and *manjistha*. Rate of dyeing is found to be sharp for 45 – 60 mins period of dyeing. Higher rate of dyeing is observed upto 60 min dyeing time in case of double mordanting system. This may be due to possible reduction in activation energy required for absorption and fixation of dyes on fibre surface by jute hemicellulose complex formation.

Keeping other dyeing variables constant, with increase in dyeing temperatures (60^oC – 100^oC), the data shown in Table 3 shows that the surface colour strength increases measurably for increase in dyeing temperature from 60^oC to 100^oC. Increase in temperature of dyeing inevitably supplies more energy usually facilitating higher rate of dye sorption for double mordanting system in general upto a certain limit of the dyeing temperature, before desorption starts. That maximum temperature is 100^oC.

Corresponding data in Table 5 indicate that, keeping all other dyeing variables remaining constant, with increase in dyeing temperatures ($60\text{-}100^oC$), the surface colour strength increases measurably upto 90^oC and then falls. So for jute, K/S value is maximum at 90^oC. The increase in temperature of dyeing supplies more energy usually facilitating higher rate of dye absorption general upto certain limit temp., before dye desorption starts.

Data in Table 5 interestingly shows varying degrees of crests and troughs in the trends of K/S value for *tesu* dyed jute fabric with variation of pH values between 4 – 11. With increase in pH from 4.0, K/S value increases upto pH-10 and then falls. However, colour fastness properties are found to be relatively better at pH – 11.0.

In case of *manjitha* dyed jute fabric, corresponding data in Table 5 show that increase in K/S value linearly with increase in pH. At pH-11, K/S value is maximum. So, pH – 11 is optimum value found from the result.

For variation of material to liquor ratio (MLR) from 1: 10 to 1 : 50 for dyeing jute fabric by *tesu*, Table 5 shows that initially the K/S value sharply increases upto MLR of 1:20 and then it gradually drops down for further increase of MLR. So, the optimum MLR is found to be 1:20. In case of *manjistha* dyed jute fabric, data in Table 3 show that for variation of material to liquor ratio (MLR) from 1:10 to 1:50, initially the K/S Value is highest at MLR – 1:10- and then is gradually reduced for further increase of MLR from 1:20 to 1:50. However, considering a balance between dye uniformity and K/S value obtained, the optimum MLR is found to be 1:20.

In case of double mordanted jute fabric dyed with *manjistha* shows slow but gradual increase in K/S value with increase in mordant concentrations upto 20% dose of mordants before showing the leveling off trend for double mordanting system. Use of more than 20%

fibre mordant concentration some strength loss has been occurred. So the optimum concentration of moradant should be 20%.

Data in Table 5 shows slow increase in K/S value with increase in concentrations of extracted dye liquor from *tesu* upto 50% (on the basis of % solid *Tesu* powder), above which it almost levels off reaching almost the saturation level. So, optimum cane is 50%.
Corresponding data in Table 3 shows gradual increase in K/S values with increase in concentrations (on the basis of % dry solid mass of Manjistha i.e. source material) extracted dye liquor from Manjistha reaching almost saturation level for use of 40% Manjistha colour concentration in case of double mordanting system. So, for jute, K/S value is maximum at 40% dye concentration level and then falls.

Data in Table 5 indicates that the optimum concentration of common salt for *Tesu* dyed jute fabrics is 10 g/L, as the K/S values are found to be maximum for use of this concentration of salt in the dye bath. The addition of an electrolyte (common salt) to the dyeing liquor in the dye bath in case of dyeing with a mordantable anionic dye like *Tesu* extract expectedly increase the exhaustion of the dye on the cellulosic or ligno-cellulosic fibres. They dissolve completely in the aqueous dye liquor at different temperature of dyeing and increase the force of repulsion between the dye molecules and water so that the dye molecule are more attracted to the cellulosic or ligno-cellulosic fibres. But higher amount of salt/electrolyte above a certain limit causes retardation effect in the dye absorption.

Corresponding data in Table 5 show that optimum common salt concentration is 10 gpl, as the K/S value is found to be maximum for use of this concentration of common salt in the dye bath. After that K/S value decreases. The addition of an electrolyte (common salt) to the dyeing liquor in the dye bath in case of dyeing with a mordantable anionic dye like *Manjistha* expectedly increase the exhaustion of the dye on the cellulosic or lingo cellulosic fibre. But higher amount of common salt/electrolyte causes retardation in dye absorption.
From this study of process variables, in case of *tesu* dyed jute fabric, it maybe therefore summarized that the observed optimum conditions of dyeing are time 60 min, Temp. 100^oC, MLR 1:20, pH – 11, mordant cone – 20%, concentration of dye (% of colour source material) 50% and concentration of common salt 10 g/L for double mordanting system. For *manjistha* dyed double mordanted jute fabric respective optimum dyeing conditions are 60 min time, 90°C temperature, MLR 1:20, pH 11, mordant cone – 20%, concentration of dye (% of colour source material) 40% and concentration of common salt 10 g/L

Conclusions

- Among the different fibre-mordanting systems studied, the use of 10-20% (owf) *myrobolan* and ferrous sulphate as double mordant for subsequent dyeing with jackfruit wood extract (30%) and 10-20% (owf) *myrobolan* and $Al_2(S0_4)_3$ as double mordant for subsequent dyeing with 20% of jackfruit wood extract show maximum *K/S* values as compared to other selective single and double mordanting systems.
- The optimized conditions of dyeing of both bleached jute and cotton substrates with jackfruit wood extract are: 90 min dyeing time for all the mordanting systems; 70^oC dyeing temperature for mordanting systems (A), (B) and (B′) and 90^oC for mordant (B);

1:30 MLR, for all the fibre-mordanting systems; 11.0 *p*H for all the fibre-mordanting systems; 20% (owf) mordant concentration for the fibre-mordanting systems (A) and (A′) and (B′), and 20-30% for fibre-mordanting system (B) and 15 gpl common salt concentration for all the fibre-mordanting systems

- The optimized conditions of dyeing of bleached jute substrates with *tesu* extract are: 60 min dyeing time for double mordanting systems; 100°C dyeing temperature; 1:20 MLR ; 11.0 *p*H ; 20% (owf) mordant concentration for the double fibre-mordanting systems (*myrobolan* followed by aluminium sulphate); 20-40% dye concentration for all the fibre-mordanting systems and 10 gpl common salt concentration for all the fibre-mordanting systems
- The optimized conditions of dyeing of bleached jute substrates with Manjistha are: 60 min dyeing time; 90°C dyeing temperature; 1:20 MLR, ; 11.0 *p*H; 20% (owf) mordant concentration, and 20% for all the fibre-mordanting systems and 10 gpl common salt concentration for all the fibre-mordanting systems.

Acknowledgement

The authors are thankful to Prof. S K Sett, Head of the Deptt. Department of Jute & Fibre Technology, Institute of Jute Technology, University of Calcutta, Kolkata, for encouragement and all administrative support to carry out the research work.

References

1 Dedhia E M, *Colourage*, 45 (3) (1998) 45.
2 Ghosh P, Samanta A K & Das D, *Indian J Fibre Text Res*, 19 (1994) 277.
3 Cook Gordon J, *Handbook of Textile Fibres: Natural Fibres*, 5th edn (Merrow Publishing Co.Ltd, England), 1993,16 & 35.
4 Samanta A K, Konar A & Datta S, *Indian J Fibre Text Res*, 36(3) (2011) 67
5 Samanta A.K, Singhee D & Seethia M, *Colourage*, 50 (10) (2003) 29.
6 Gulrajani M L & Gupta Deepti, *Natural Dye and their Application to Textiles* (Deptment of Textile Technology, IIT Delhi), 1992, 25.
7 Mahale G Sakshi & Sunanda R K, *Indian J Fibre Text Res*, 28 (2003)86.
8 Katti M R, Kaur R & Shrihari N, *Colourage*, 43 (12) (1996) 37.
9 Gulrajani M L, Bhaumik S, Oppermann W & Hardtmann G, *Indian J Fibre Text Res*, 28 (2003) 221.
10 Mathur P J, Mehta A, Karnawar R & Bhandari C S, *Indian J Fibre Text Res*, 28 (2003) 94.
11 ISI (BIS) Handbook of Textile Testing, 1st edn (Bureau of Indian Standards, New Delhi), 1982 ; revised edn, (1986), 221,255,536,553 &573.
12 David G Duff & Roy S Sinclair, Giles's Laboratory Course in Dyeing ,4th edn (Society of Dyers and Colourists, Bradford, UK), 1989,120-121.
13 Bird C L and Boston W S, The Theory of Colouration of Textiles, The Dyers Company Publication, UK, 1975 55,166,167,169,185,536,553 & 571
14 Data book on Jute, (National Institute of Research on Jute and Allied Fibre Technology, Kolkata), 1st edn, 1999,21.
15 Palit S R, Elementary Physical Chemistry, 12th edn (P.C Bhowal, Kolkata), 1991, 149
16 Arshid F M, Desai J N, Duff D J, Giles C H, Jain S K and Macneal I R, J Soc Dyers Colour, 70 , 1954,392

Table 3: Brightness index, surface colour strength, colour differences and colour fastness of dyed (aq. extract of jackfruit wood 20%) jute and cotton fabrics after single mordanting with selective mordants

Mordant conc., %	Fabric	Dye conc. %	Shade obtained	Surface colour strength and colour difference			BI
				K/S value at λ_{max}	ΔE		
Nil (Control bleached fabric)	Jute	0	---	0.80	---		38.20
Nil (Control fabric)	Cotton	0	---	0.01	---		92.06
Myrobolan							
20	Jute	0	---	1.96	0.73		25.72
20	Jute	20	Creamish yellow	2.30	1.36		21.06
20	Cotton	0	---	0.08	10.49		53.81
20	Cotton	20	Creamish yellow	0.55	6.23		45.13
$Al_2(SO_4)_3$							
20	Jute	0	---	0.99	1.10		34.17
20	Jute	20	Light green	1.47	6.00		28.84
20	Cotton	0	---	0.07	1.50		88.83
20	Cotton	20	Creamish yellow	0.16	6.58		68.28
$FeSO_4$							
20	Jute	0	---	5.03	5.97		13.46
20	Jute	20	Golden brown	6.57	4.64		9.34
20	Cotton	0	---	0.06	21.02		43.91
20	Cotton	20	Golden yellow	1.09	7.97		32.72
$KAl(S0_4)_2$							
20	Jute	0	---	1.15	1.77		34.69
20	Jute	20	Light green	1.48	4.52		27.87
20	Cotton	0	---	0.04	8.88		86.38
20	Cotton	20	Creamish yellow	0.10	9.47		68.09
$SnCl_2$							
20	Jute	0	---	1.12	2.29		35.59
20	Jute	20	Light yellow	1.61	5.95		28.15
20	Cotton	0	---	0.02	5.93		75.93
20	Cotton	20	Cream	0.14	6.68		65.26
EDTA							
20	Jute	0	---	0.80	1.19		37.56
20	Jute	20	Cream	1.03	1.68		33.40
20	Cotton	0	---	0.04	7.43		87.43
20	Cotton	20	Cream	0.07	8.10		79.10
BI- Brightness index (ISO-2470)							

Table 4: Brightness index, surface colour strength, colour differences and colour fastness of dyed (aq. extract of jackfruit wood 20%) jute and cotton fabrics after sequential double mordanting with selective mordants

Mordant conc., %	Fabric	Dye conc %	Shade obtained	Surface colour strength and colour difference		BI	Colour fastness to				
				K/S value at λ_{max}	ΔE		Washing		Light	Rubbing	
							LOD	ST		Dry	Wet
Myrobolan : $Al_2(SO_4)_3$											
20:20	Jute	0	---	2.54	3.55	23.56	---	---	---	---	---
20:20	Jute	20	Greenish yellow	3.35	5.65	19.77	4	5	3	5	5
20:20	Cotton	0	---	0.08	11.5	49.71	---	---	---	---	---
20:20	Cotton	20	Light greenish yellow	0.55	7.45	49.66	5	4-5	3	5	4-5
Myrobolan : $FeSO_4$											
20:20	Jute	0	---	8.67	8.41	5.38	---	---	---	---	---
20:20	Jute	20	Blackish brown	12.21	35.2	3.79	3	5	3	4-5	3-4
20:20	Cotton	0	---	2.29	14.28	17.11	---	---	---	---	---
20:20	Cotton	20	Grey	3.99	5.11	12.51	1	3-4	1	4-5	3-5
Myrobolan : $KAl(S0_4)_2$											
20:20	Jute	0	---	2.60	4.34	24.17	---	---	---	---	---
20:20	Jute	20	Greenish brown	3.31	5.76	19.94	4	5	3	5	5
20:20	Cotton	0	---	0.10	10.6	48.70	---	---	---	---	---
20:20	Cotton	20	Light yellow	1.05	7.72	36.20	5	4-5	3	5	4-5
Myrobolan : $SnCl_2$											
20:20	Jute	0	---	2.51	3.63	25.57	---	---	---	---	---
20:20	Jute	20	Light ocher yellow	3.13	5.93	22.29	5	4-5	1	4-5	4-5
20:20	Cotton	0	---	0.06	7.39	58.88	---	---	---	---	---
20:20	Cotton	20	Light yellow	0.55	10.3	50.62	5	4-5	3	5	4-5
Myrobolan : EDTA											
20:20	Jute	0	---	1.50	2.34	27.71	---	---	---	---	---
20:20	Jute	20	Cream	1.36	0.33	27.11	4	5	2	5	5
20:20	Cotton	0	---	0.05	6.11	65.65	---	---	---	---	---
20:20	Cotton	20	Cream	0.18	8.47	62.61	5	4-5	3	5	4-5

ΔE - Colour difference, BI-Brightness index, LOD- loss of depth of shade and ST- Staining on cotton

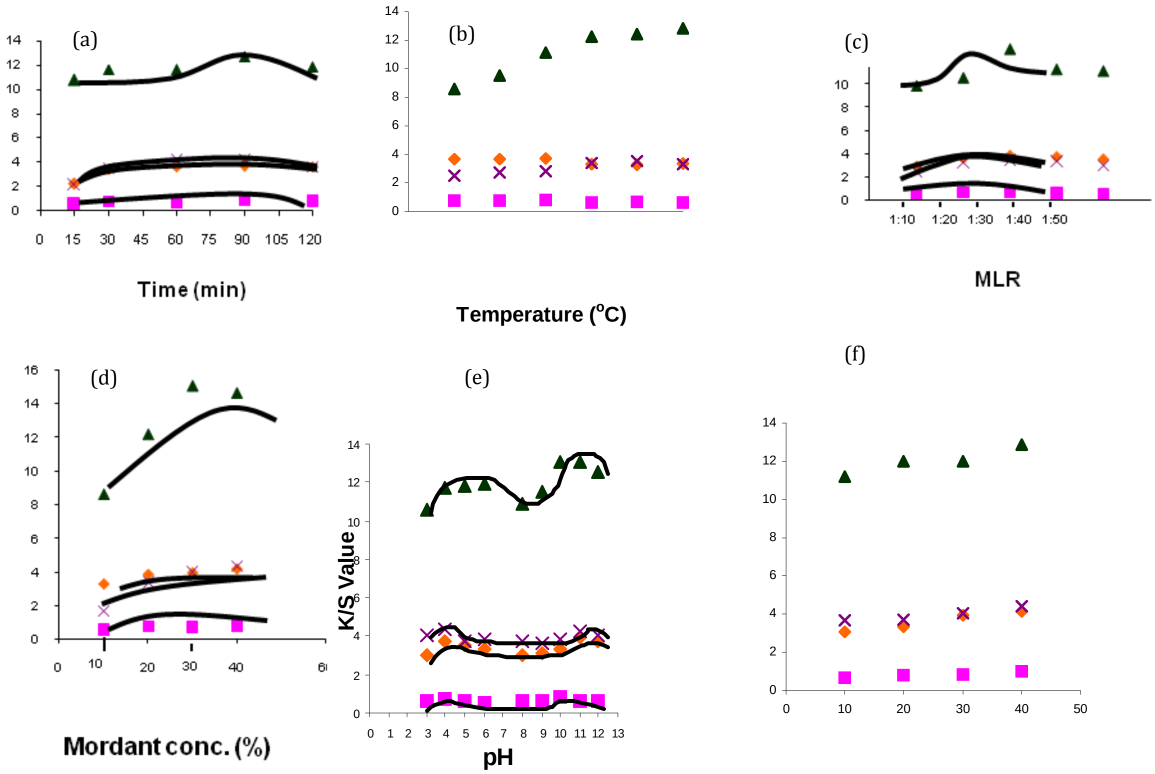
Table 5: Data showing the effects of dyeing process variables on surface colour strength and dye uniformity for pre-mordanted bleached Jute Fabric and dyed with *Tesu* & *Manjistha* separately

Name of the Variable		*Tesu* (aq. extract of flower petal powder)		*Manjistha* (aq. extract of grinded root)	
		K/S at λ_{max}	CV of K/S	K/S at λ_{max}	CV of K/S
Time (Min)	45	7.07	3.14	4.69	5.41
	60	7.63	4.21	4.25	5.91
	90	7.05	4.67	5.73	6.2
	105	7.42	5.12	5.71	5.88
	120	7.07	4.99	6.17	5.41
Temperature (^oC)	45	6.45	4.87	5.17	5.89
	60	6.25	4.97	5.64	5.96
	75	6.52	5.21	6.13	6.02
	90	7.35	5.46	6.76	6.32
	100	7.63	5.87	5.21	5.84
pH	4	5.15	4.32	4.91	5.87
	6	3.74	5.78	5.42	6.24
	8	5.63	5.02	5.98	6.48
	10	8.1	5.69	6.18	5.41
	11	7.47	5.99	6.63	6.37
MLR	1:10	6.25	3.45	6.15	4.57
	1:20	7.63	4.75	5.21	4.87
	1:30	7.27	4.98	5.19	5.21
	1:40	5.7	4.58	4.67	5.37
	1:50	6.05	4.37	4.52	5.89
Dye Concentration (%)	10	4.56	2.12	3.96	5.59
	20	5.00	4.58	4.02	5.81
	30	5.33	4.97	6.16	5.98
	40	5.96	5.36	7.41	6.11
	50	6.13	5.87	5.21	6.04
	60	6.17	6.12	5.56	5.13
Mordant Concentration (%)	10	5.44	4.27	4.61	5.69
	20	7.63	4.58	5.42	5.87
	30	5.47	5.21	5.41	5.91
	40	9.18	5.47	5.00	6.23
Salt (g/L)	5	5.39	4.41	5.68	4.20
	10	7.63	4.78	5.91	4.54
	15	5.8	4.54	5.31	5.21
	20	5.46	5.62	5.89	6.01

Table 6: Colour fastness data for pre-mordanted jute fabrics with 40% natural dyes, *Tesu* & *manjistha* and after-treated with one of three cationic fixing agent and a UV absorber

Colour Fastness		Washing									Light	Rubbing	
Dye used	Shade developed	None		2% CTAB		2% Cetrimide		2% Sandofix -HCF		None	1% Ben	None	
		LOD	ST	LOD	ST	LOD	ST	LOD	ST			Dry	Wet
Manjistha	Reddish	3	3-4	4	5	3-4	4-5	4	4-5	4	5	4-5	2
Tesu	Yellowwis hbrown	2	2-3	4	3-4	3-4	4-5	4	3-4	2	3	4	2

CTAB – n – Cetyl-trimethyl Ammonium Bromide
Ben – Benztriazole, LOD = Loss of depth of Shade; ST – Staining of adjacent bleached jute



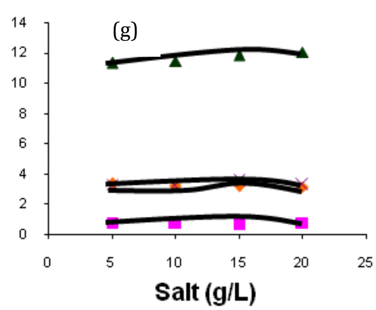


Fig.1– Effects of dyeing process variables on colour strength of jute and cotton fabrics dyed with jackfruit wood extract after double pre-mordanting with selective mordants.

Jute-Harda + $Al_2(SO_4)_3$ (A)

Jute-Harda + $FeSO_4$ (B)

Cotton-Harda+$Al_2(SO_4)_3$ (A|)

Cotton-Harda+ $FeSO_{43}$ (B|)

Concurrent dyeing and finishing of silk with natural colour and itaconic acid in the presence of potassium sodium tartrate and potassium persulphate as catalysts under thermal treatment

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Abstracts

Silk fabric was simultaneously finished and dyed with itaconic acid and *Punica granatum* in the presence of potassium sodium tartarate as the esterification catalyst and potassium peroxodisulphate as the free radical polymerisation catalyst following dip-dry-iron-cure technique. Presoaking of silk fabric with 0.5% of potassium peroxodisulphate and subsequent treatment with a solution containing 8% itaconic acid , 8% potassium sodium tartrate and 20% punica granatum at 70^0C for 30 min, air drying of treated silk, ironing of dried silk at 70^oC and finally curing of ironed silk at 140^oC for 5 min produced most balanced improvements in the properties of silk fabric in respect of depth of shade, wrinkle recovery and colour fastness, wash and rubbing with retention of about 90% of original strength.

***Keywords*: ** Colour fastness**,** *Punica granatum*, Potassium peroxodisulphate, Potassium sodium tartarate.

Introduction

Polycarboxylic acid compounds offer an alternate route for toxic formaldehyde condensate resin for improvement of wrinkle recovery of silk [(1-4)]. Such compounds have evoked immense interest in the recent past in view of their environment friendly and non toxic characters. However sodium salts of phosphorus containing mineral acids used as esterifications with such polycarboxylic acid compounds are not environment friendly [(5-7)] as they give rise to eutrophication and other environment related problems.

Pomegranate is the name of a sweet juicy fruit of genus punica. *Punica granatum* is cultivated in tropical and subtropical parts and available in abundance in India. The skin of such fruits is red to brown on colour and colouration of textiles can be done using such colour of the skin when extracted with water. Fruit rind contents about 45% *Ellagi annin flavogallol.* [(8-9)]

In view of the above it is thought to be of interest to dye and finish silk fabric by combination of i) esterification, ii) chain polymerisation and ultimate cross-linking in consequent to application of aqueous solution of punica granatum and a readily polymerisable acid such as itaconic acid under the influence of potassium sodium tartrate as phosphorus free esterification catalysts and potassium peroxodisulphate as free radical polymerisation catalyst. Results of related studies are reported in the present article.

Materials and Methods

Materials

Plain weave bleached loom state silk fabrics having 204 picks/dm and 212 picks/dm, 50g/m^2 in weight is used for the study. Punica granatum dye, obtained from M/s ALPS Industries India was used after purifying it by dissolving in methanol, followed by filtration and recrystallisation. All the chemicals used in the study were of laboratory reagent grade.

Degumming and bleaching of silk

The loom state silk fabric was degummed at 900C for 1.5 hour in an aqueous solution containing soap (6.0 g/L) and sodium carbonate (2.0 g/L). the degummed silk samples was bleached at 850C for 1 hour in a solution containing hydrogen peroxide (0.9%), non silicate stabiliser (0.15%) and sodium carbonate (0.1%). Material –to-liquor ratio for both degumming and bleaching operations was maintained at 1:20. Bleached sample was washed at 700C for 10 mins, cold washed and finally dried.

Concurrent dyeing and finishing of silk with pomegranate and itaconic acid

Silk fabric were dyed and finished simultaneously following exhaust-dry-iron-cure technique. Silk fabric was presoaked with a solution containing 5g/L of potassium peroxodisulphate and subsequently dipped and worked in an aqueous bath containing pomegranate solution (20% owf), 6% itaconic acid, 10% potassium sodium tartrate. Treatment was carried out at a MLR 1: 20 at 70^0 C for 30 mins. The treated fabrics were then given a squeeze and were allowed to dry in air. The dried fabric was then ironed at 70^{0}C and finally cured in a hot air oven at 140^{0}C for 5 mins. The cured fabrics was subsequently washed in cold water and dried in air.

Determination of fabric stiffness

Fabric stiffness, as expresses by the bending length of the selected fabric sample, was measured as per IS: 6490-1971 (cantilever test) in a SASMIRA Stiffness Tester with a specimen size of 25mmx200mm.

Determination of MR and weight gain after treatment

Moisture regain of the initial and treated silk fabrics determined following a standard procedure (Annual book of ASM standards 1974). For the determination of weight gain upon finishing treatment using itaconic acid the finished fabric samples were first soap washed and then extracted under reflux in a water bath for 8-10 hour successively using water to ensure removal of traces of un-reacted itaconic acid monomer along with polymeric itaconic acid that remain unbound or un-grafted to the chain molecules of the silk fabric samples. The extracted fabric samples were then oven dried to a constant weight (w1) at

100^0C. The weight gain (%) was then calculated on the basis of initial dry weight of degummed silk (W2) using the following relationship weight gain (%) = $(W_1-W_2)/W_2$ x 100

Measurement of tensile properties

Breaking strength of some selected fabric samples was measured in a Zwick 1445 CR Universal Tensile Testing Machine, according to a method[8] (Handbook of Textile Testing, 1981) prescribed by IS; 1969 – 1968. The results obtained were based on an average of 10 tests in the warp direction of each sample. The test strip specimens were ravelled to a size of 50mm x 20mm between the jaws of the machine, and the tests were performed with a traverse speed of 100 mm min^{-1} at a pretension of 0.5 N.

Determination of wrinkle recovery angle

Dry wrinkle recovery angle (warp + weft) of selected fabric samples were determined according to a method prescribed by ASTM-D-1295-67 using a SASMIRA Wrinkle recovery tester with specimen size of 25mm x 200 mm.

Determination of fabric stiffness

Fabric stiffness, as expresses by the bending length of the selected fabric sample, was measured as per IS: 6490-1971 (cantilever test) in a SASMIRA Stiffness tester with a specimen size of 25mm x 200 mm

Result and discussions

Silk fabrics were dyed with *Punica granatum* following a exhaust-dry-iron-cure technique in the presence of varying concentrations of itaconic acid separately taken in a dye bath as specified. In all such applications of itaconic acid as mordanting and silk finishing agent itaconic acid : potassium sodium tartrate concentrations was maintained 1:1 (w/w) and silk fabric was presoaked in an aqueous solution of 0.5% potassium peroxodisulphate prior to dyeing for all the application of itaconic acid as specified in Table 1. Potassium sodium tartrate in the dyed bath was employed as esterification catalyst with the expectation that such catalyst will bring about esterification reactions between carboxylic acid groups of itaconic acid and hydroxyl groups of natural dye and also with serine and tyrosine amino acid fractions of silk under the treatment (dyeing) conditions employed. Potassium peroxodisulphate has been employed with the expectation that the same would initiate free radical polymerization of itaconic acid during dyeing of peroxodisulphate treated silk fabric. Relevant data are shown in Table 1.

Table 1: Effect of itaconic acid application level on dye receptivity and mechanical properties of silk fabric dyed with *Punica granatum*

Itaconic acid	Potassium sodium tartrate	Weight gain	k/s (λ=420 nm)	Wrinkle recovery angle	Tensile Strength retained	Bending length
(%)	(%)	(%)		(%)	(%)	(cm)
0	0	4.32	3.14	178	96	1.4
2	2	6.51	4.07	196	80	1.4
4	4	9.12	8.02	218	86	1.3
8	8	13.39	9.71	241	91	1.3
10	10	15.16	10.06	246	93	1.3
12	12	17.43	10.34	248	95	1.3

For the application of *Punica granatum* following an exhaust-dry-iron-cure technique it appears with increasing dose level of itaconic acid shade depth expressed in terms of k/s and wrinkle recovery of the silk fabric followed a common increasing trend with the final leveling of effect in most of the cases at itaconic acid application level of 8%. It is interesting to note that the weight gain data followed also increasing trend with increasing dose level of itaconic acid and the values of weight gain in all the cases were observed to be substantially higher than the respective itaconic acid application level for almost all doses of itaconic acid application shown in Table 1. Such high weight gain achieved higher than the corresponding itaconic acid application level is the consequence of improved uptake of the punica granatum under the application condition as evidenced and supported by k/s value of the corresponding dyed silk fabrics.

Tensile strength retention suffers a fall for 2% application of itaconic acid which however followed an increasing trend thereafter with increase of dose level of itaconic acid further beyond an application level of 2%. Flexibility of the silk fabric as revealed by bending length (Table 1) remained unaltered for 2% itaconic acid application level which thereafter remained at a marginally reduced level for all other itaconic and applications ranging from 4-12% studied in this experiment.

The high wrinkle recovery angle and k/s value observed for dyeing of silk fabric in presence of itaconic acid are the consequences of esterification of dye and silk fabric in a manner that would lead to i) cross-linking of two dye molecule ii) cross-linking of silk fabric and iii) linking of dye and silk fabric via itaconic acid. Such esterification reactions are found to be much more pronounced and effective in promoting wrinkle recovery angle and k/s value of the silk fabric in presence of peroxodisulphate catalyst only as evident from the data given in Table 1. Peroxodisulphate catalyst acted as free radical polymerisation catalyst bringing about self polymerisation of itaconic acid and graph copolymerization of itaconic acid on silk fabric during dyeing at 90^0C that caused an overall change in environment and the proximity of the hydroxyl groups of the silk and carboxyl groups of unbound or silk bound itaconic acid or poly (itaconic acid) moieties in a manner that finally causes an enhanced degree of potassium sodium titrate catalyst esterification reaction leading to substantial cross-linking of i) silk fabric ii) *Punica granatum* and linking of dye and silk fabric is much improved manner as evident from the data given in Table 1.

Study of IR spectroscopy (data not shown) further supported the reactions detailed in the above explanation.

Comparison of properties of silk fabrics dyed with Punica granatum in the presence of inorganic salts and itaconic acid

Table 2 gives data of the properties of silk fabrics dyed with Punica granatum following exhaust-dry-iron-cure technique in i) absence and ii) presence of inorganic salts. It also gives data about the properties of silk fabrics dyed with *Punica granatum* in presence of itaconic acid. Table 2 clearly indicates that dyeing of silk fabrics with *Punica granatum* in the presence of itaconic acid produced much over all improvements in the fabric quality; itaconic acid under the catalytic influence of peroxodisulphate and sodium potassium tartrate specifically imparts higher k/s (colour yield) value and higher wash, light and rubbing fatness rating with appreciable improved wrinkle recovery for the silk fabric.

Itaconic acid under the influence of esterification catalyst introduces effectively ester linkages between the silk fabrics and dye molecules under the treatment conditions in consequence to reaction of its carboxyl groups with hydroxyl groups of dye and silk, in addition to establishment of cross linkages between the polymeric chains of silk and that between the dye molecules. Such crosslink dye molecules and chemical bound dye molecules to the silk fabric offer high resistance to the action of washing and rubbing leading to improvement in the above two fastness properties. High light fastness rating obtained for silk fabric dyed in presence of itaconic acid is due to aggregation of dye molecule in consequence to crosslinking and reduced diffusion of oxygen and moisture into cross linked silk affected commonly by itaconic acid under the treatment condition[9].

Table 2: Comparison of properties of silk fabrics dyed with *Punica granatum* in the presence of itaconic acid and inorganic salt

Silk dyed with	In the presence of	k/s (λ=420 nm)	Color appeared on the substrate	Wrinkle recovery angle (^{0})	Colour fastness properties		
					WF	LF	RF
Punica granatum	None	1.54	Yellow	176	3-4	3	4-5
	Aluminium sulphate	3.90	Yellow	176	4	4-5	4-5
	Ferrous sulphate	5.21	Yellow-brown	177	3-4	4	4-5
	Itaconic acid and Potassium sodium tartrate	9.71	Yellow-brown	241	4-5	4-5	5

Note: WF: Wash fastness, LF: Light fastness, RF: Rubbing fastness

Conclusion

Simultaneous dyeing and finishing of silk with *Punica granatum* and itaconic acid establishes an environment friendly route for achieving an improved dyeing and modification of silk with high scope for incorporation of much improved physical and mechanical properties. The major property advantages that can be derived by such treatments by following a exhaust-dry-iron-cure technique under the catalytic influence of potassium sodium tartrate and $K_2S_2O_8$ are substantial gain in wrinkle recovery, colour yield, colour fastness properties, properties to light, washing and rubbing with associated retention of high order of tensile strength.

References

1. Bose T K, Mitra S K, & Sanyal D, *Fruits: Tropical and sub tropical*, 3rd edn. Vol II (Naya Udyog, Kolkata), 2002, 127
2. Singh A, *Fruit physiology and production*, 4th edn. (Kalyani Publishers, New Delhi), 1997, 432-435.
3. EL- Nemr SE, Ismail I A & Ragab M, Nahrung, 34 (1990) 601-606.
4. Bhattacharyya N & Vairagi S, *Colourage*, 49(4) (2002) 47
5. Das D, Samanta AK & Dasgupta PC, *Indian Journal of Fibre & Textile Research*, 22(1) (1997) 53-60
6. Gulrajani ML, Gupta DB, Agarwal V & Jain M, *Indian Textile Journal*, 102(10) 1992, 778-83
7. Das D, Bhattacharya S C, Maulik S R, *Indian Journal of Fibre & Textile Research*, Vol 31, Dec 2006, PP 559-564
8. Ghosh P, Das D, Samanta AK, *Journal of Polymer Material* 1995, 12, 297
9. Allen NS (1987), *Photofading mechanism of dyes in Solution and polymer medias*, *The Review of progress in Coloration*, 17, 61-71

Natural dye and the historical concept of Tie-dye —— the first fabric design of human civilization

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Abstract

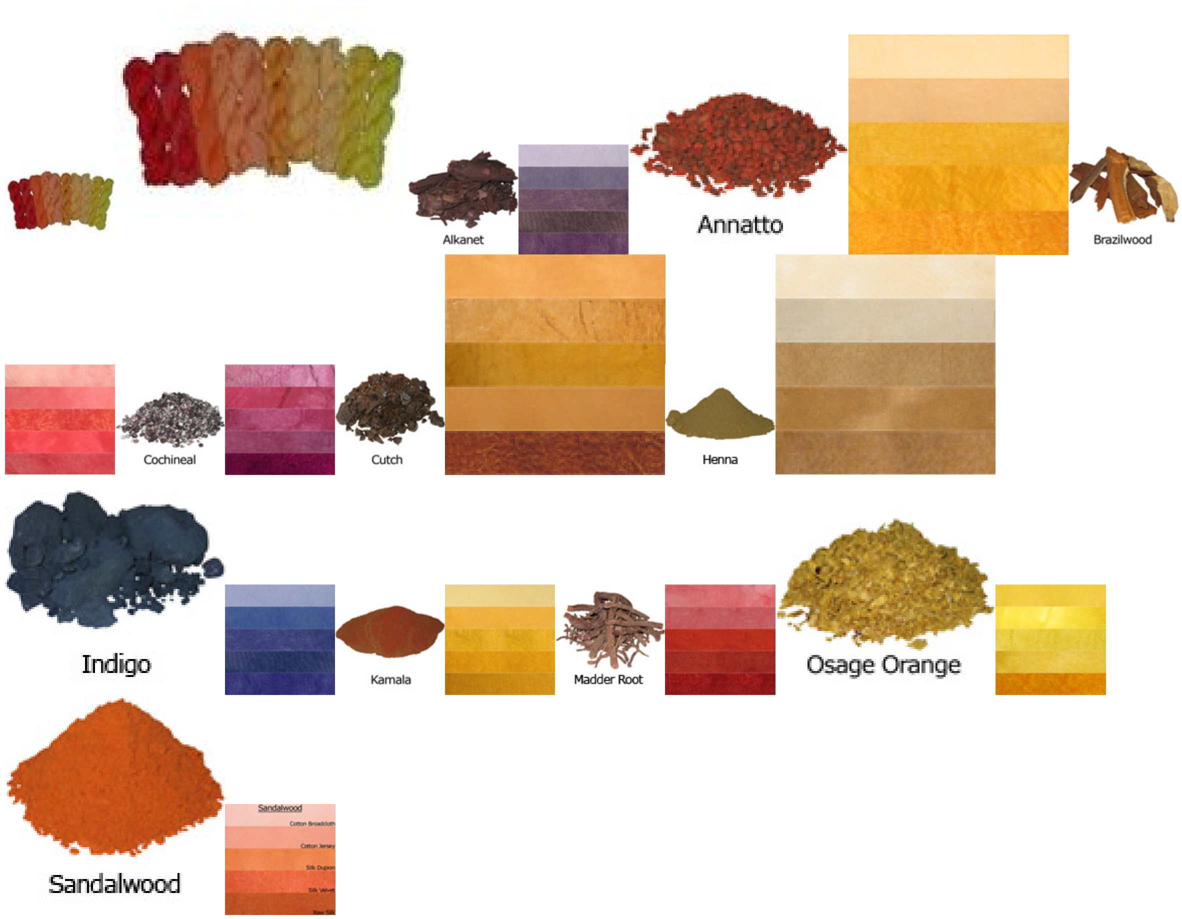
A naturally dyed organic textile is non-toxic and safe for everyone. It is biodegradable and eco-friendly. Tie-dye dates back to ancient times. Tie-dye became fully developed in China during the Tang dynasty (618-906 A.D.) and in Japan during the Nara period (552-794 A.D.). The availability of silk and hemp, which are very receptive to the resist technique, made these countries' art outstanding. Some early tribes in Western China, South East Asia, and Central America tied and dyed the threads before weaving their cloth. Varied styles of tie-dye have emerged to distinguish the different nations of Africa. The Indian tie-dye technique called *Bandhani*, or *Bandhni* or *Bandhej*, is the oldest tie-dye tradition which is still in practice. The Malay-Indonesian name for this technique is *Plangi*.

Keywords: Bandhni, Ikat, Non-toxic, Tie-dye.

Introduction

Natural dye has a long and rich history stemming from almost every human civilization culture. It is important because it utilizes naturally occurring materials to create color without the use of chemicals or salt. A naturally dyed organic textile is non-toxic and safe for everyone. At the end of its life, it is biodegraded back into the soil without hurting the earth. Tie-dye dates back to ancient times along with beads, shells, and other ornamentation, our ancestors tie-dyed. Think to the story of Joseph, son of Jacob, in the Bible's Old Testament. He had a beautiful coat of many colors; the envy of his brothers. Could it have been tie-dyed? Tie-dye became fully developed in China during the Tang dynasty (618-906 A.D.) and in Japan during the Nara period (552-794 A.D.). The availability of silk and hemp, which are very receptive to the resist technique, made these countries' art outstanding. Some early tribes in Western China, South East Asia, and Central America tied and dyed the threads before weaving their cloth. When it was woven into material, beautiful designs appeared where the white lines of the tie contrasted with the colored dyes. This method is known as *ikat*. Early dyes were extracted from roots, flowers, leaves, and berries. These include blackberries, lichen, safflower, marigold, onion, red cabbage, sage, and indigo. Although these dyes are still used today, synthetic dyes have been developed that are permanent, quick-setting, safe, easy to use, and are ensured by accurate formulas. As in ancient times, we still use natural fibers for tie-dyeing. Silks from China, cottons from Egypt, and rayon from Bali are still highly prized. Hemp has always been used as a durable and dyeable natural fabric. The following picture shows some common sources of natural dyes:

Natural Dyes (from plants and insects)



Tie-Dye in Asia

The tie-dye methods using cotton and silk were passed down in Japan, Indonesia, and Southeast Asia, while cotton and raffia were used in many parts of Africa. Pre-Columbian Peruvians used wool and cotton to make *ikat* designs in their weaving. From 1568 to 1603, in what's known as the Momoyama period, *tsujigahana* reached its height. This is an art combining tie-dye with ornamental drawing using Chinese ink called *sumi*. Tie-dye may be the entire design, or it can be used to create large areas where flowers, landscapes, and trees are drawn into the designs. Traditional dye shops developed new methods such as *shibori* for making elegant silk robes. At that time, Japan was divided into kingdoms. Raids against neighboring kingdoms were common. Warlords would give gifts of recognition to officers displaying bravery in these battles, and of the most prized was a tie-dyed kimono or *kosode*.

These have been passed down in some families as prized possessions, and many can be found in museums today. The natural dyes have faded, but the designs of flowers and detailed misty landscapes are spectacular. These kimonos exhibit interesting variations in the use of tie-dye. One variation was the creation of a white area by tying off a large piece of the material before dyeing. Ink would then be used to draw pictures on the white area. In another design, rice would be tied into the material in little circles, so that when the material was dipped in blue dye mainly Indigo, designs of little white circles would be scattered over the deep blue kimono.

Tie-dye of other countries —— the 60's and beyond

Other forms of tie-dye can be found in other countries around the world. Varied styles of tie-dye have emerged to distinguish the different nations of Africa. The Indian tie-dye technique called *Bandhani*, also known as *Bandhni* and *Bandhej*, is the oldest tie-dye tradition which is still in practice. The Malay-Indonesian name for this technique is *Plangi*. The technique involves a design made of dots, in which many small points are tied with thread before immersion dyeing. In the U.S. during the Roaring '20s, pamphlets were printed that gave directions on how to decorate home with tie-dyed curtains and pillows. During the Depression, girls cut up cotton flour sacks, tie-dyed them, and then sewed them into clothing, curtains, and tablecloths. When times are rough, tie-dyeing has been a way to brighten peoples' lives. Tie-dye came back in style in the 1960's when a great movement emerged among young people that emphasized individuality. It was time to "do your own thing." Each person could make a statement by tie-dyeing clothes with a personal combination. Tie-dyed sheets were used as room dividers and wall hangings. Silk and cotton banners were used as backdrops for rock and roll concerts. Since the 1980's, tie-dye has seen a reemergence as style and as a highly skilled, difficult and labor intensive art form. Many different colors can now be put on one item to get intricate detailed designs in brilliant colors. The dyes, which used to fade so badly, have been replaced by dyes that are permanent and easier to use. They can be in bright rainbows, toned down blues, purples, or earth tones. Pastels are perfect for someone with more conservative tastes. Designs are endless and always completely unique. Japan and Indonesia is now the best design maker of Tie dye.

Conclusion

The tie-dye methods using cotton and silk were passed down in Japan, Indonesia, and Southeast Asia, while cotton and raffia were used in many parts of Africa. The technique involves a design made of dots, in which many small points are tied with thread before immersion dyeing. Each person could make a statement by tie-dyeing clothes with a personal combination. The basic motifs of design came from Tie dye effect in modern era.

Picture of Tie Dye in modern style

Revolution of Colors: Impact on our fragile environment

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Abstract

Colors have played a large role in cultural practices throughout human history, and this trend is no different today. Fabrics are dyed with a variety of colors to help us express emotion and distinguish status. Until the mid-1800s, all dyes originated from natural, plant-based material. After the creation of synthetic dyes, there was a true revolution of color. Colors became easier to produce and apply, leading to a rapid expansion of colors throughout society. Unfortunately, this revolution of color extends beyond society and into the natural world. There is growing evidence that the processes used to create these synthetic dyes are having detrimental effects on the environment. Bodies of water are being polluted, which has adverse effects for all plant and animal life present. Additionally, human health has been compromised by the toxic properties that many of these chemicals possess. In this paper, we address the impacts that the manufacturing of synthetic dyes has on the environment and human health. We also discuss alternatives to the use of synthetic dyes and cite steps currently being taken to reduce the use and harmful effects these dyes have on the environment.

Key words: Chemical pollution, Dye effluent, Environmental impacts, Natural dyes, Synthetic dyes.

Historical Background

Throughout history, humans globally have used natural dyes to distinguish social classes (serfs and masters). Historically, dyeing was a secretive art form; the most beautiful and exotic pigments were reserved for those who had the status to wear them. Use of dyes was not restricted to clothes and garments only. Complex multitudes of colors, derived from natural sources have been used for ceremonial purposes by tribes such as the Navajo Indians in the USA, the *Tirio* and Maroon tribes in Suriname, South America, and during ceremonial face paintings among several indigenous tribes around the world, including the delicate and complex face paintings seen among the "*Kathakali*" dancers in India. Indeed, color from plants of one sort or another can be seen in use throughout recorded history and across cultural and geographical divides. From the Scythian burial mounds on the borders of southwest Mongolia, textiles preserved in ice and dating from the 5th century B.C. reveal an extensive and sophisticated use of vegetable dyes (Eiland 1979).

Records of the use of natural dyes date back to as a far as 2600 B.C. in China. The medieval world also used dyes extensively and dyes were an extremely important part of medieval trade. One tree was the *Sappanwood* (*Caesalpinia sappan*) which was said to produce a high quality red dye and was favored by the Portuguese who named it "Bresil" or "Brasil". When they landed in South America, it was replete with *Sappanwood* trees and they called the land, Brazil. In 1856, while trying to synthesize artificial quinine, 18-year-old chemistry student William Perkin instead produced a strangely beautiful color. Perkin had stumbled across the world's first aniline dye, a color that became known as mauve! Perkin built a factory near London to supply the world's first synthetic dye. Synthetic versions of alizarin and indigo, dyes previously derived from plants, followed. Although England had the early lead, Germany soon became the leading global supplier of a rainbow of brilliant colors.

Prior to 1856, the only textile dyes available were those that could be found in nature. Things began to change when scientists discovered how to make synthetic dyes. Cheaper to produce, brighter, more color-fast, and easy to apply on fabric, these new dyes changed the way we perceived colors. Scientists raced to formulate gorgeous new colors and before long, dyed fabric was available to all, and natural dyes had taken a back seat and become obsolete for most applications.

To most eyes, the world was brightly colored. Reds, blues, mauves, lavenders, cyans, fuchsias, magentas, to name a few, dominated the fabric tastes of the populace. To suite your fancies, you could even have a color 'blended' to your taste. Hence, the world took on a colorful decor. This changed new world, full of colors created through complex chemical reactions, was not without a down side however.

Why are Synthetic dyes so harmful?

In a paper published in the journal Scientific American in 1910 entitled "Fast and Fugitive Dyes: Something about their Chemistry", Dr. Otto Witt goes in length to elucidate the misconception that all natural dyes are fast and all synthetic dyes are fugitive. As early as that time period, the paper correctly highlights the fact that all dyes essentially belong to the same family of chemicals and that all are subject to same laws of chemistry. However, what matters the most in light of present day concerns, is the origin of the "color-molecules".

Synthetic dyes are so problematic because the families of chemical compounds that make good dyes are also toxic to humans, other animals, and plants. Each new synthetic dye developed is a novel compound, and because it's new, no-one knows its risks to humans and the environment. Many dyes like Amaranth have entered the market, and then have subsequently been discovered to be carcinogenic and withdrawn. The European Union in particular has been pro-active in banning dangerous dyes and dyes formulated from toxic chemicals.

The chemicals used to produce dyes today are often highly toxic, carcinogenic, or even explosive in some cases. Scientists have shown that there are a number of harmful chemicals used in the dying process including dioxin —— a carcinogen and possible hormone disrupter, toxic heavy metals such as chrome, copper, and zinc and formaldehyde, a suspected carcinogen. The chemical Aniline, the basis for a popular group of dyes known as Azo dyes which are considered deadly poisons (giving off carcinogenic amines) and are dangerous to work with, since they are highly flammable. Aniline Yellow was the first azo dye. It was first produced in 1861 by C. Mene. The second azo dye was Bismarck Brown in 1863.

Aniline Yellow was commercialized in 1864 as the first commercial azo dye, a year after Aniline Black.

In addition to the dyes themselves, the garment finishes are often equally as harmful. We will save discussion on garment finishes for another post, but just briefly, they are used for creating wrinkle-free, stain resistant, flame retardant, anti-static, anti-fungal, anti-bacterial, odor-resistant, permanent-press, and non-shrink fabrics. They can also be used as softening agents, and for creating other easy-care treatments. In fact it is often the dye fixative, used to bond the dye color to the fabric, which causes the most problems. All of these can be particularly challenging for people with chemical sensitivities.

Environmental impacts of synthetic dye manufacturing

Synthetic dye chemicals have caused or fueled many dye factory fires throughout history, including a massive Rhode Island, USA dye factory fire in 2003 in which vast quantities of dye chemicals spilled into the Blackstone River. In 1912, Dr. William G. Beckers, a German chemist, had started a small dye works in the Flatbush section of Brooklyn, New York. This plant was wrecked by an explosion in 1914 that killed two chemists. The strong demand for dyes, along with financial aid from capitalist Eugene Meyer, Jr., convinced Beckers to build a much larger plant in the Canarsie section of Brooklyn. The company was known as the Beckers Aniline & Chemical Works and employed 1,200 men. The Beckers firm merged into the National Aniline & Chemical Company in 1917. Dr. Beckers became one of the wealthiest industrialists of the era and retired in 1920 to a palatial estate in Lake George, New York. But pollution from the Brooklyn plant contributed to the end of oyster harvesting in the nearby Jamaica Bay. This was an early warning sign of the environmental problems that would taint the dye industry and erode public support.

Clearly, there is a huge historical precedent for considering vegetable colors as a serious alternative to present-day sources, and their production on an industrial scale is by no means impossible. In 1864, the United Kingdom imported upwards of 40,000 tons of logwood (*Haematoxylon campechianum*) - a subtropical tree grown principally in the West Indies and South America and from which was extracted a variety of blues, purples and blacks. Britain also imported around 19,000 tons of madder (*Rubia tinctoria*), 13,000 tons of sumac (*Rhus coriaria*) and 3,000 tons each of indigo (*Indigofera tinctoria*) and Quercitron oak bark (*Quercus velutina*) during the same period (Rhind 1872). This was the quantity needed to meet demand of a single country about 147 years ago. Now, if we extrapolate this to provide us an estimate of what today's needs might be, it will be an astronomical figure, (about 72 gigatons of madder in one year alone) given the population increased three times within this period and it would be a safe assumption to make that so did the demand for textile. And this estimate is for the United Kingdom only. What would be the quantity needed to meet global demands? Do we have enough arable land to meet the agricultural demands of the ever increasing population of the planet and then some to grow plants to yield the dyes? What about the economic feasibility of such an undertaking?

Let us get to the reality, natural dyes will never be able to completely replace synthetic dyes, due to several intertwined factors. The fact that there is only so much land to go around and food is already in great demand is just one of them. However, there are innovative ways of using plants for multiple purposes and maximizing their dying potential, such as genetic engineering.

So, what is it in the synthetic dye manufacturing process that hurts the environment? Back to basics, almost all industrial dye processing involves a solution of a dye in water, in which the fabrics are dipped or washed. However, what is interesting is not the process until this, but rather what happens after this is where the concern lies. After dying a batch of fabric, it's cheaper to return the used water to its source without much or any cleansing/processing/chemical unloading – dye effluent, than it is to clean and re-use the water in the factory. While there are countries where strict measures are enforced to ensure that the effluents meet the clean standards, several countries also lack such measures and pose a threat to the environment. With global outsourcing, it is very difficult to track if the protocols of effluent treatment are followed in the countries where the manufacturing has been outsourced.

For example, in August 2007, the Chinese government investigators crawled through a hole in the concrete wall that surrounds the Fuan Textiles mill in southern China and launched a surprise inspection of the plant. Authorities discovered a pipe buried underneath the factory floor that was dumping roughly 22,000 tons of water contaminated from its dyeing operations each day into a nearby river, according to local environmental-protection officials. Villagers say that fish died, and the lifeless river turned to sludge. What they found caused alarm at dozens of American retailers, including Wal-Mart Stores Inc., Lands' End Inc. and Nike Inc., which use the company's fabric in their clothes (Spencer 2007).

Prices of fabric and clothing imported to the U.S. have fallen 25% since 1995, partly due to the downward pricing pressure brought by discount retail chains. One way China's factories have historically kept costs low is by dumping waste water directly into rivers. Treating contaminated water costs upwards of about 13 cents a metric ton, so large factories can save hundreds of thousands of dollars a year by discharging waste water directly to rivers in violation of China's water-pollution laws. Similar violations have been reported by CBS News 2010, about a textile dying plant (mainly jeans) in Lesotho in southern Africa, where contaminated effluent was seen leaking into the ground water-table and a local river. Certain textile factories in Mexico have also been found guilty of letting rivers near jeans factories turn dark blue from untreated, unregulated dye effluent. Local residents and farmers report health problems and wonder if the food they are obliged to grow in nearby fields is safe to eat anymore.

What's the Alternative to Synthetic Dyes?

So what is the dye industry doing, or rather innovators in the clothing industry who want to change the dye industry? Responsible dye manufactures are investigating ways to treat their dye effluent with organic materials and bacteria, rather than chemical treatments, and improve dye manufacture and processing to minimize hazardous chemicals used.

Natural, plant based dyes are steadily making a comeback into mainstream fashion. In the United States, government legislation aims to replace at least a portion of the petroleum-based oils in lithographic inks used on government documents with an ink based on vegetable oil. According to the Vegetable Printing Act of 1994, the increased use of vegetable oils would reduce reliance upon non-renewable energy resources, use fewer environmentally damaging products, reduce volatile organic compound emissions and increase the use of renewable agricultural products [25].

However, once all the factors are taken into consideration, including those that concern the overall well-being of the planet, then any alternative resource ought not to be ignored. Indeed, there are a number of initiatives (such as phytochromography - Shawn 1999, shift from solvent-based to aqueous-based printing, physicomechanical treatments of effluents, to name a few - Lacasse and Baumann, 2004) currently being pursued throughout Europe and the United States that demonstrate the seriousness with which governmental institutions have taken the issue of vegetable-sourced alternatives in the dyeing and printing industries.

Some Interesting Facts

- Religious paintings always depicted the Virgin Mary in blue robes particularly ultramarine which was the most expensive natural dye.
- A natural dye name Tyrian purple was the most expensive dye in the ancient times and relegated to royalty alone. Tyrian purple, a natural dye, is made from Mediterranean shellfish and was extensively used in the ancient Phoenician city of Tyre. It takes approximately 8,500 shellfish to produce one gram of this dye. The dye is also mentioned in the Bible.
- Species of scaled insects, Cochineal, is used to produce deep red or crimson and was probably used by the Aztecs and the Mayans.
- Red fabric was discovered at Tutankhamen's tomb which was found to be dyed with madder, a plant-based dye.
- Alexander the Great, when he conquered Susa around 541 BC, talks of the discovery of purple robes.
- In the biblical Book of Exodus, Kermes (from the Kermes insect) is mentioned as the source of scarlet colored linen.

References

1. Chemical Sensitivity Foundation. 4 Wren Drive, Topsham, Maine USA. (http://www.chemicalsensitivityfoundation.org/ : accessed on Nov. 4th 2011)
2. Eiland, M. L. 1979. Chinese and Exotic Rugs. 246 pages. A. Zwemmer Ltd. London
3. Lasasse, K. and W. Baumann. 2004. Textile chemicals: environmental data and facts. 1180 pages. Springer, Heidelberg, Germany.
4. Rhind, W. A History of the Vegetable Kingdom. 1857. 690 pages. Harvard University Press. Cambridge, Massachusetts USA.
5. Shaw, P. 1999. Phytochromography: Screen Printing with Plants: Research into Alternative Ink Technology. Leonardo, Vol. 32, pp. 33-39
6. Spencer, J. Aug 22, 2007, Page A1. Raved Rivers - China pays steep price as textile exports boom. The Wall Street Journal, New York, USA.
7. Vegetable Printing Act of 1994. United States Congress House Committee on Government. Washington, USA.

Natural and vegetables dyes in Northeastern part of India

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Abstract

The art of natural and vegetable dyeing is seen in India from time immemorial. The biggest proof is the *Ajanta* paintings where the painting itself was done using natural colours, as chemical colours were not available at that time. Therefore, it proves that the primitive people there knew the art of dyeing using natural dyes. At the Northeastern region of India, this art is seen in nearly all villages be it Meghalaya, Nagaland, Mizoram, or Auranachal-Pradesh, etc. During the field work, the author has an opportunity to learn more about the know-how. But it is dying now. In this paper, the author would like to create some awareness by sharing his experience.

Keywords: Ajanta painting, Chemical colours, Natural dye.

Dyeing of cotton yarns with *Latkan* wood, *Hena, Lac* and *Turmeric*

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Abstract

In today's world, where there are imminent threats to the environment from toxic synthetic chemicals and dyes a thorough introspection of scientific achievements towards alternative and eco-friendly natural products is very essential. Hence, the environment scientists and chemical technologists are trying to create an eco-friendly atmosphere throughout the globe. Naturally, this has also created ripples in the world of textile science where natural products in general and natural dyes in particular are heading towards a period of renaissance. Keeping this background information in mind, an attempted has been done in the present work to dye cotton yarns in pink, green, red and purple shades (as per customer's demand at that period). In this work *Henna*, *Latkan* wood, *Turmeric* and *lac* dyes were used to produce the targeted shades. From the above study it may be concluded that the yarns dyed with *Latkan* wood, *turmeric*, *lac* and *henna* produces different shades of pink, red, yellow, grey and green of varying shades with different mordants when mordanted with *myrobolan*, aluminium sulphate and ferrous sulphate. Further the cotton yarns dyed with the above mentioned dyes also had good fastness properties in terms of wash fastness, light fastness and rubbing fastness rating.

***Keywords*:** Fastness, *Henna*, *Lac*, *Latkan* wood, Mordants, Natural Dyes, *Turmeric*.

Introduction

In today's world, where there are imminent threats to the environment from toxic synthetic chemicals and dyes a thorough introspection of scientific achievements towards alternative and eco-friendly natural products is very essential. Probably this concern has prompted many researchers to delve deeper into the nature once again and in fact, to meet these impending threats. Hence, the environment scientists and chemical technologists are trying to create an eco-friendly atmosphere throughout the globe. Naturally, this has also created ripples in the world of textile science where natural products in general and natural dyes in particular are heading towards a period of renaissance.

In the early 21st century, the market for natural dyes in the textile/ apparel/ fashion industry is also experiencing a resurgence [1] as consumers have become more concerned about the health and environmental impact of synthetic dyes and there is a growing demand for natural textile products (from natural fibres like cotton, silk, wool, jute) dyed with natural dyes. Thus it is seen that the alchemy of colour has its origin deeply rooted thousand of years ago. From the epic age this colour had played a very important role in human life. This inspired many researchers to explore the vast store house of the nature's palette to initially dye the apparels. It is highly pleasing to know that India was a forerunner in the art of natural dyeing an art perfected in the era of the epics. Today, when the world is facing threats of destruction from the synthetic toxic chemicals, eco-friendly awareness should be inculcated; else, it would be difficult to save this planet from complete extinction. Here, lies the relevance of this art of dyeing with natural colourants. With this background information in mind, it has been attempted in the present work to dye cotton yarns in pink, green, red and purple shades (as per customer's demand at that period). In the present work *Henna*, *Latkan* wood, *Turmeric* and *lac* dyes were used to produce the targeted shades.

Materials and Methods

Materials

Cotton yarn

100% bleached (white) cotton yarn of 80^s and100^s English count in the form of hanks were used in the following experiment.

Chemicals and dyes used

The chemicals used included *myrobolan* (Harda i.e. Haritaki) powder, Ferrous Sulphate & Aluminium sulphate. The natural dyes used for the present work include *latkan* wood (biological name *Bixa orellana*) and *Henna* powder (biological name *Lawsonia intermis*), lac (biological name *Kerria lacca)* and *turmeric* (biological name *Curcuma longa*).
Fig. 1, 2, 3 & 4 shows the chemical structures of the above mentioned dyes:

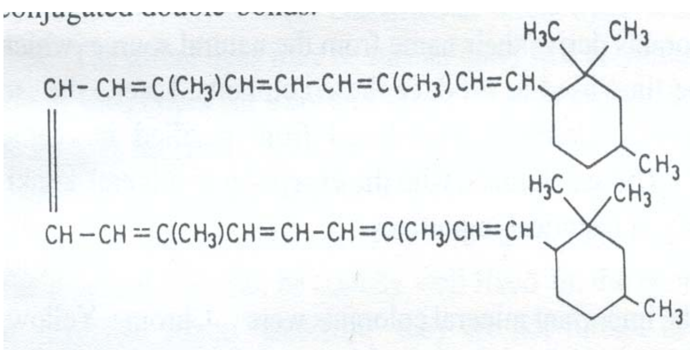

Fig. 1: *Latkan*(C.I.40888)

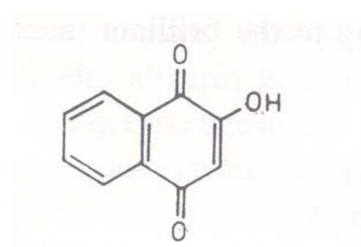

Fig. 2: *Henna* (C.I.75480)

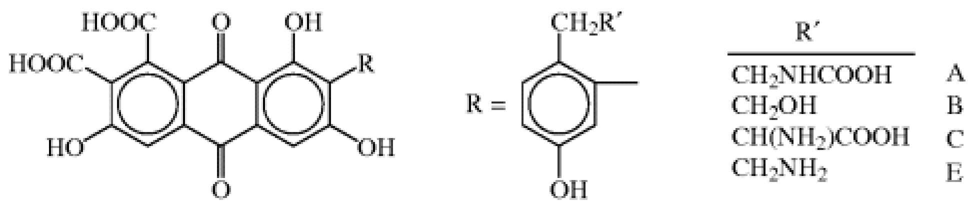

Fig. 3: *Lac* (C.I.75450)

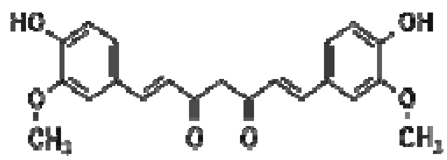

Fig. 4: *Turmeric* (C.I. 75300)

Methods

Dyeing of cotton yarn with *Latkan* wood & *Henna*

Extraction procedure of natural dyes used

The extraction of the dye was done by boiling the *Latkan* wood, *turmeric*, *lac* or *henna* in water for 1hr at 100°C and then the dye solution was sieved to get the clear solution of the dye.

Mordanting of the yarn

The cotton yarn was mordanted using pre-wetted sieved solutions of either *myrobolan* or in combination of *myrobolan*, ferrous sulphate, aluminium sulphate and natural alum by treating the yarns for 1hr at 100°C in the mordanting bath. The first mordanting of the yarns were done by treating the yarns in *myrobolan* mordanting bath and the second mordanting was done by treating the yarns in ferrous sulphate/aluminium sulphate/natural alum mordanting bath.

Dyeing of yarns

The cotton yarns were dyed with the dye solution of either *Latkan* wood, *turmeric*, *lac* or *henna* by boiling the yarns in the dye solution for 1hr with or without addition of salt of requisite amount. Then the samples were rinsed with cold water and finally with non-ionic soap solution at 60°C for 15min so as to remove the unfixed dye from the surface of the yarn.

Washing of dyed yarns

The dyed cotton yarns were subjected to multiple (2-5) wash cycles following ISO-II method of washing [2].

Measurement of surface colour strength

The surface colour strength [3] (K/S value, indicating dye shade depth) was determined by measuring corresponding reflectance value using Macbeth 2020 plus reflectance spectrophotometer and by calculating the K/S value using the Kubelka-Munk equation. The colour difference [6] was measured by L*, a*, b* values using colourlab plus software and Macbeth 2020 plus reflectance spectrophotometer using the CIE-Lab equation. The light fastness of the dyed cotton yarn samples was evaluated as per IS: 2454-1967 [3]. Dry and wet rubbing fastness of the dyed cotton yarn was evaluated as per IS: 766-1956 method [4].

Determination of wash fastness, light fastness and rubbing fastness

The wash fastness rating of the dyed cotton yarn was assessed as per the IS: 3361(1979) and IS: 764(1979) methods after washing the samples following the ISO-II method of washing (for ISO-II: Soap-5gpl, 50±2°C, material–to-liquor ratio-1:20 for 45min) [2] using SASMIRA Launder-o-meter.

Results and discussions

Effect of various mordants in dyeing with Latkan wood

The cotton yarns mordanted with *myrobolan* solution and dyed with *latkan* wood produced light pink colour whereas the yarn first mordanted with *myrobolan* and second mordanted with aluminum sulphate produced baby pink colour and the yarns first mordanted with *myrobolan* and second mordanted with ferrous sulphate produced magenta colour. It was further noted that with increase in the percentage of concentration of mordant from 5% to 10 % in case of the second mordanting with ferrous sulphate and aluminium sulphate there is increase in shade depth which is expressed in terms of K/S values shown in Table-1 and the shade card.

Effect of various mordants in dyeing with Henna

The cotton yarns mordanted with *myrobolan* solution and dyed with *Henna* produced light *pista* colour whereas the yarn first mordanted with *myrobolan* and second mordanted with aluminum sulphate produced *pista* colour and the yarns first mordanted with *myrobolan* and second mordanted with ferrous sulphate produced shabby green colour. It was further noted that with increase in the percentage of concentration of mordant from 5% to 10 % in case of the second mordanting with ferrous sulphate and aluminium sulphate there is increase in shade depth which is expressed in terms of K/S values shown in Table 2 and the shade card.

Effect of various mordants in dyeing with Lac

The cotton yarns mordanted with *myrobolan* solution and dyed with *lac* produced light pink colour whereas the yarn first mordanted with *myrobolan* and second mordanted with aluminum sulphate produced brilliant red colour and the yarns first mordanted with *myrobolan* and second mordanted with ferrous sulphate produced grey colour. It was further noted that with increase in the percentage of concentration of mordant from 5% to 10 % in case of the second mordanting with ferrous sulphate and aluminium sulphate, there is increase in shade depth which is expressed in terms of K/S values shown in Table 3 and the shade card.

Effect of various mordants in dyeing with Turmeric and finally topped with Lac

The cotton yarns mordanted with *myrobolan* solution and dyed with turmeric produced light yellow colour whereas the yarn first mordanted with *myroblan* and second mordanted with aluminum sulphate produced brilliant yellow colour and the yarns first mordanted with *myrobolan* and second mordanted with ferrous sulphate produced greyish yellow. Again this treated and dyed samples when was further dyed with *lac* dye solution further produced faded red, chrome red and reddish grey colour. It was further noted that with increase in the percentage of concentration of mordant from 5% to 10 % in case of the second mordanting with ferrous sulphate and aluminium sulphate there is increase in shade depth which is expressed in terms of K/S values shown in Table 4 and the shade card.

Effect of wash fastness test on various dyed yarns dyed with Latkan wood, Lac, Turmeric and Henna

The yarns dyed with latkan wood, lac, turmeric and Henna had fastness properties from moderate to good when measured manually by grey scale to change in colour and grey scale to staining and was also measured by using reflectance spectrophotometer in terms of K/S values shown in Table 1, 2, 3 & 4.

Effect of light fastness test on various dyed yarns dyed with Latkan wood, Lac Turmeric and Henna

The yarns dyed with *latkan* wood, lac, *turmeric* and *Henna* had fastness properties from moderate to good when measured manually by grey scale to change in colour and was also measured by using reflectance spectrophotometer in terms of K/S values shown in Table 1, 2, 3 & 4.

Effect of Rubbing Fastness test on Various Dyed Yarns Dyed with Latkan wood, Lac, Turmeric and Henna

The yarns dyed with *latkan* wood, *lac*, *turmeric* and *Henna* had fastness properties from moderate to good when measured manually by grey scale to change in colour and grey scale to staining and was also measured by using reflectance spectrophotometer in terms of K/S values shown in Table 1, 2, 3 & 4.

Conclusion

From the above study it may be concluded that the yarns dyed with *latkan* wood, *turmeric*, *lac* and *Henna* produces different shades of pink, red, yellow, grey and green of varying shades with different mordants when mordanted with *myrobolan*, aluminium sulphate and ferrous sulphate. Further the cotton yarns dyed with the above mentioned dyes also had good fastness properties in terms of wash fastness, light fastness and rubbing fastness rating.

Acknowledgement

The author (SMR) is thankful to Mr. B. Biswas, Proprietor, Associated Exports and the then Principal, Institute of Jute Technology and present Head of the Department of Department of Jute & Fibre Technology, IJT, University of Calcutta for permitting her in carrying out this work in these two organizations. The author is also thankful to the Principal, Rani Birla Girls' College, Kolkata for permitting her to attend and read this paper in this seminar.

References

1. Calderin, Jay, *Form, Fit, Fashion (*Rockport), 2009, 125.
2. *Handbook of Textile Testing*, SP-15-1981(Bureau of Indian Standards, New Delhi, India), 1982, 278.
3. Samanta A K, *Indian text J*, 105(1995)50.
4. Samanta A K, *Fundamental of Instrumental colour measurements, colour tolerances and introduction to computerized colour matching, paper presented at the short Course on Bleaching, Dyeing, Printing & Finishing of Jute*, Institute of Jute Technology, Kolkata, June 1994.
5. *ISI (BIS) Hand Book of Textile Testing*, 1st ed., SP-15-1981(*Bureau of Indian Standards*, New Delhi, India), 1982, pp 536, 553, 571.

Table 1: Surface colour strength, colour difference and brightness index values at different stages of dyeing and colour fastness of cotton yarn dyed with *Latkan* wood

Mordant	Colour	K/S	ΔE	BI	Colour fastness			
	(Main hue)	At □max			Wash	Light	Rubbing	
							Dry	Wet
Control (bleached cotton yarn)	---	0.01	---	92.0	--- ---	---	---	---
10% myrobolan	---	0.08	8.49	53.8	--- ---	---	---	---
10% myrobolan + Latkan wood	pink	1.00	6.91	34.05	4-5	4	5	4-5
20% $Al_2(SO_4)_3$	---	0.02	1.50	88.8	--- ---	---	---	---
10 % $Al_2(SO_4)_3$+ Latkan Wood	Baby pink	1.18	6.96	30.63	4-5	4	5	4-5
10%myrobolan + 10 % $Al_2(SO_4)_3$	---	0.08	11.55	49.7		---	---	---
10%myrobolan + 10 % $Al_2(SO_4)_3$+ Latkanwood	Magenta	1.61	6.99	23.30	4-5	5	5	4-5
10%myrobolan + 10 % Fe_3SO_4 + Latkanwood	Pnkish red	1.46	6.76	23.71	4-5	5	5	4-5

Table 2: Surface colour strength, colour difference and brightness index values at different stages of dyeing and colour fastness of cotton yarn dyed with *Henna*

Mordant	Colour	K/S	ΔE	BI	Colour fastness			
	(Main hue)	at □max			Wash	Light	Rubbing	
							Dry	Wet
Control (bleached cotton yarn)	---	0.01	---	92.0	--- ---	---	---	---
10% myrobolan	---	0.08	8.49	53.8	--- ---	---	---	---
10% myrobolan + Henna	Light pista green	1.55	6.23	45.1	4-5	4	5	4-5
10% $Al_2(SO_4)_3$	---	0.02	1.50	88.8	--- ---	---	---	---
10 % $Al_2(SO_4)_3$+ Henna	Pista green	1.10	6.58	48.2	4-5	4	5	4-5
10%myrobolan + 10 % $Al_2(SO_4)_3$	---	0.08	11.55	49.7	---	---	---	---
10%myrobolan + 10 % $Al_2(SO_4)_3$+ Henna	Light green	1.05	7.72	36.2	4-5	4	5	4-5
10%myrobolan + 10 % Fe_3SO_4 + Henna	Shabby green	7.41	15.4	12.28	4-5	4	5	4-5

Table 3: Surface colour strength, colour difference and brightness Index values at different stages of dyeing and colour fastness of cotton yarn dyed with *Lac*

Mordant	Colour	K/S	ΔE	BI	Colour fastness			
	(Main hue)	at □max			Wash	Light	Rubbing	
							Dry	Wet
Control (bleached cotton yarn)	---	0.01	---	92.0	--- ---	---	---	---
10% myrobolan	---	0.08	8.49	53.8	--- ---	---	---	---
10% myrobolan + Lac	Light pink	1.00	6.91	34.05	4	4	5	4-5
10% $Al_2(SO_4)_3$	---	0.02	1.50	88.8	--- ---	---	---	---
10 % $Al_2(SO_4)_3$+ Lac	Dark pink	1.18	6.96	30.63	4	4-5	4-5	4-5
10%myrobolan + 10 % $Al_2(SO_4)_3$	---	0.08	11.55	49.7		---	---	---
10%myrobolan + 10 % $Al_2(SO_4)_3$+ Lac	Pinkish Red	1.46	6.76	23.71	4-5	5	4-5	4-5
10%myrobolan + 10 % Fe_3SO_4 + Lac	Reddish Grey	3.59	9.4	12.19	4-5	5	4-5	4-5

Table 4: Surface colour strength, colour difference and brightness index values at different stages of dyeing and colour fastness of cotton yarn dyed with *Turmeric* and combination of *Turmeric* and *Lac*

Mordant	Colour (Main hue)	K/S at □max	ΔE	BI	Colour fastness Wash	Light	Rubbing Dry	Wet
Control (bleached cotton yarn)	---	0.01	---	92.0	--- ---	---	---	---
10% myrobolan	---	0.08	8.49	53.8	--- ---	---	---	---
10% myrobolan + Turmeric	Light yellow	5.57	11.1	10.8	3-4	3-4	3-4	3-4
10% $Al_2(SO_4)_3$	---	0.02	1.50	88.8	--- ---	---	---	---
10 % $Al_2(SO_4)_3$+ Turmeric	yellow	2.84	12.0	17.0	3-4	3-4	3-4	3-4
10%myrobolan + 10 % $Al_2(SO_4)_3$	---	0.08	11.55	49.7		---	---	---
10%myrobolan + 10 % $Al_2(SO_4)_3$+ Turmeric	Dark Yellow	4.73	11.2	13.3	3-4	3-4	3-4	3-4
10%myrobolan + 10 % Fe_3SO_4 + Turmeric	Yellowish Grey	6.24	13.8	8.27	3-4	3-4	3-4	3-4
10%myrobolan + 10 % $Al_2(SO_4)_3$+ Turmeric + Lac	Brilliant red	1.61	6.99	23.30	3-4	3-4	3-4	3-4

Batik on cotton fabric with natural dyes

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Abstract

Batik work is sill now limited in mainly Naphthol colour and partly in solubilised vat dye, because both of them can be applied on fabric in cold condition. The excellence of batik work is its natural creation of crack design with the help of wax which is a good resisting material. Batik with natural colour is not practically possible as during steaming, which is a must after printing, wax melts down and it becomes very difficult to remove it from the fabric. In this work an attempt has been taken for batik work with natural colour which has a huge demand in our country and abroad in the present day due to its eco-friendliness. Normally printing with natural dye have been tried in many cottage sector using block and screen but wax being the unavoidable substance in batik work, which gives us unique design, has not yet been tried due to the above mentioned reason. In spite of that this attempt has been done for the sake of innovation of technique so that the work can be brought to a more or less success.

***Keywords*:** Batik, Natural dye, Naphthol colour, Solubilised vat dye.

Introduction

Natural dyes comprise those colorants which are obtained from vegetable, mineral or animal sources without any chemical processing [1]. The use of natural dyes on textiles has been known since ancient history. Dyeing of textile fibres were already been reported around 1000 B.C and those dyes were obtained from berries, blossoms, barks and roots of the plants. But after the discovery of synthetic dye in the mid of nineteenth century by Perkin, use of natural dyes for coloration of textiles had been declined as efforts were mainly directed towards the development and manufacturing of new synthetic dyes by different dyestuff manufacturers. The enthusiasm of using synthetic dyes for colouation of textiles had developed because of the well known limitations of natural dyes [2]. But now-a-days with the increasing awareness of the environmental pollution and health hazards associated with the synthesis and processing of synthetic dyes has caused the environmentalists to raise the call "go back to the nature". Some of the synthetic dyes contain toxic/carcinogenic amine or other such groups which are harmful to human body. In contrast to this, most of the natural dyes are based on vegetable origins which are agro-renewable, bio-degradable and eco-friendly in nature (except few which contain objectionable hazardous chemicals). Most of the natural dyes with a few exceptions require mordant for fixing them on to the substrates and to achieve better fastness properties. Mordants also help to produce different range of shades by using a single colourant. But an attention towards pollution control is very essential while using those different metallic salts. Salts of magnesium, calcium, aluminium, zinc, ferrous are comparatively safe than chromium, lead, arsenic and copper.

Batik work is still now limited in mainly Naphthol colour and partly in Solubilised Vat dye, because both of them can be applied on fabric in cold condition. The excellence of batik work with the help of wax is its natural and unique crack design. Batik with other colour is not practically possible as during steaming, wax is melted. The present article is based on an attempt to carry out batik work on cotton fabric with natural colour because of its demand in export market and eco-friendliness. Normally printing with natural dye has been carried out in many cottage sectors using block and screen. But batik work with natural colour which gives us unique design on the fabric has not yet been tried.

Materials and methods

Cotton fabric
Plain weave loom state cotton fabric was used in the present article.

Natural dyes
Onion skin, Turmeric and Harda were used as vegetable colourants for this work.

Chemicals
Aluminium sulphate, ferrous sulphate and copper sulphate were used as mordanting agents. All other chemicals used in this study were either of laboratory reagent grade or of commercial grade.

Methods

Combined scouring and bleaching

Combined scouring and bleaching of desized cotton fabric was done as per the standard method.

Dyeing of cotton fabric

Dyeing of bleached cotton fabric was carried out at 90^0C for 45 minutes keeping a material to liquor ratio of 1:20 in an open bath beaker dyeing machine. After dyeing the fabric was mordanted with specified inorganic salts. The mordanting process was carried out at 70^0C for 25 minutes. After mordanting the fabric sample was cold washed and soaping was done with 2 g/l non-ionic detergent at 50^0C for 10 minutes. Finally it was dried in air.

Wax coating and dyeing

The dyed fabric was coated with molten wax and crack design was created at places as intended. The fabric was then dipped in cold dye solution for two minutes and in inorganic salt solution for another two minutes. The process may be repeated twice or thrice according to the required depth of cracks. After completion of this process the fabric was steamed for 15-20 minutes at 102^0C temperature.

Removal of wax

For better removal of wax from the fabric after steaming, the fabric was ironed at a very high temperature keeping the fabric in between two news papers. All most 90% wax was transferred to paper and rest 10% of wax was removed by boiling with non-ionic detergent 5-7 minutes.

Conclusions

- The process of batik work is an innovative method which produces a unique design on the fabric.
- Since the removal of wax is not an easy process, hence reuse of the removed wax is not possible.
- Though found costly, it may be suitable for producing specialty products in cottage sector.
- Copper Sulphate should be used below the permissible Eco-Marks level.

References

1. S Ray Maulik and L Bhowmik, Dyeing of jute and cotton with some selective natural dyes, *Man Made Text India*, 49 (1), (2006), pp 23-29.
2. S Ray Maulik and L Bhowmik, Studies on application of some vegetable dyes on cellulosic and lignocellulosic fibre, *Man Made Text India*, 49 (4), (2006), pp 142 – 148.

Mata-ni-Pachedi'- 'Kalamkari' of Gujarat

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Abstract

Mata-ni-Pachedi, (cloth behind the idol of Mother) is a sparsely known art practiced by Vaghari community in Ahmedabad. The worshipers are leather workers, farm laborers, sweepers etc and Vagharis themselves. They made shrines by using these pieces and sung the glory of Mata and made animal sacrifices if their wishes were fulfilled. All the materials, (dyes, cotton fabric and *kalam*) used in the creation of *Mata-ni-Pachedi* are organic. Traditionally only black and red was used to create mythological stories of *Mata* in an orderly format of columns and rows. *Pachedis* always had an architectural rendering of a temple at its center which also housed the main mother goddess image-austere, stern, many armed with weapons and powerful. Under her is her mount or vehicle. She is their protector against evil. They use iron rust for black, alum for red and boiled the fabric in alizarin to get red and fix black. Dhawda flowers were used to retrieve whiteness of the left out areas. Then the fabric was washed in the running wares of Sabarmati River. With time other colours, liberty of composition, and refined lines became a part of Mata-ni-Pachedi. Today only a handful of artisans are continuing the tradition.

***Keywords*:** Artisan, Kalamkari, *Mata-ni-Pachedi.*

Introduction

Mata-ni-Pachedi, is a sparsely known art practiced by *Vaghari* community. It represents the art history, creativity and cultural heritage of this community now settled in Ahmadabad. All the materials used in the creation of *Mata-ni-Pachedi* are organic. The dyes, the cotton fabrics, the *Bawal* stick *kalams* are all made up of naturally available products. Extremely eco-friendly in its nature, *Mata-ni-Pachedi* reinforces the use of non-polluting, wholesome materials which do not compromise in making outstanding aesthetic pieces. Unfortunately, unlike other temple hangings or block printed textiles of the country, *Mata-ni-Pachedi* never obtained much of a significant position in the history of Indian textiles.

Mata-ni-Pachedi

Although Gujarat is known for its exquisite embroidery, the lesser known art of *Kalamkari* is equally appealing and unique. When one thinks of *Kalamkari* it is usually associated with the one that is done in Andhra Pradesh, predominately portraying a variety of Hindu narrative themes, from the Ramayana and Mahabharata. *Kalamkari* in Gujarat differs from that done in South with its central theme – the Mataji. The term *Mata-ni-Pachedi* came from the Gujarati words, ***'Mata,'*** 'goddess' ***'ni'***, 'belongs to', ***'Pachedi,'*** which literally meant 'behind' in Gujarati.

A *Mata-ni-Pachedi* for the nomadic *Vagharis* served the purpose of a portable shrine. The fact that these temple hangings were used to form a shrine for the goddess instead of being hung behind an icon, made them unique. Traditionally, the shrine cloths are made for ritual use by members of castes such as leather workers, farm laborers, sweepers, or by the *Vagharis* themselves. *Vaghari* community gradually settled on the outskirts of towns/ villages as they shifted from a semi-nomadic stage to a fixed state. Even today, *Mata-ni-Pachedi* serves as a rear wall to the main shrine for this community, who still follow their original style of worship.

When any of the *Mata's* devotees suffers illness or misfortune, he goes to the *Mata's* shrine and vows to make a sacrifice to her if she will relieve him of his trouble. If his wish is granted, he pays for the shrine to be cleaned and decorated, and an enclosure made up of *Pachedis* is erected, with the *Chandarvo*, the great square shrine canopy, draped above it. This was followed by singing the glory of *Mata* and the ritual sacrifice: the cooking and eating of a young goat. There is always a depiction of a *bhuvo* **(**priest), leading a sacrificial animal to the *Mata*, on a *Pachedi*, or *Chandarvo***.** The **'***Chitaras'* are the artists who painted the shrine hangings, and **'***Jagorais'* are the singers who interpreted the *Pachedis*. A ceremony of chants and a trance-inducing dance was conducted by a priest-shaman, known as a **'***Bhuvo'*.

Although the technique of making the *Mata-ni-Pachedi* or the *Mata-no-Chandarvo* is now practiced only by a handful of *Vaghari* families settled in Ahmedabad and in Kheda district, the craft was previously prevalent in the region of Aghar and Dholka as well. In addition to catering to the commissions received from a number of ethnic communities such as the *Bharwad*, the *Koli*, the *Rawal*, the *Vaghri*, the *Rabari* and the *Deviputar*, the craftsmen also practiced direct selling by visiting places such as Dholka, Dhanduka, Barda, Limdi, Rajkot and Bhavnagar during Navratri.

Pachedis are on display at the Lalbhai Dalpatbhai Museum and Calico Museum in Ahmedabad. Baroda Museum and Art Gallery in Vadodara also exhibit *Pachedis***.**

Mythology and Composition

In a great battle between *Shiva* and the *asura* Raktabija, every drop of the *asura's* blood that fell to the earth, gave rise to more and more demons. The gods then turned to *Shakti***,** to annihilate the *asuras*. The fierce goddess pierced the demon's body and drank all his blood, thus saving both the worlds. Thus the goddess *Shakti*, the destroyer of evil is always depicted with weapons in all her ten arms looking fierce and commanding, invoking awe and fear in the onlooker. Sometimes she carries a bowl of blood in one of her arms.

Both the *Pachedi* and the *Chandarvo* are always framed with a bold border, which is divided into a line of single color and a band of decorative linear patterns which is colloquially termed as a **'***lassa patti'*. Traditionally *Pachedis* always had an architectural rendering of a temple at its center which also housed the main mother goddess image —– austere, stern, many armed and powerful. Under her is her mount or vehicle. Around this were panels of incidents linked to the *Puranic* myths of the central deity as well as scenes from daily life. In a lower caste, community, which also was barred from entering a built shrine or possessing their own literary collection this, was an ingenious solution. The themes, stories, dimensions and proportions of the motifs are interpreted differently according to the artist's sensibility and visualization.

Some believe that the Goddess have a hundred forms, others say it is sixty-four. She is depicted in any of these along with the appropriate iconographic details and attributes. The Goddess in seven forms is worshipped during the nine days of *Navaratri* festival. Some of the names are *Amba Ma, Momai Ma, Dasha Ma, Bahuchar Ma, Karka Ma, Meledi Ma, Hadaksha Mata.*

A *Chandarvo* being a ceiling cloth, the painted pattern is a representative of the magic circle, the *garbha*. The Mother Goddess occupies a central position with myths and incidents in circular patterns around the central figure.
The most common motifs, apart from *Mataji* astride a mount, include lady with a flower, the *paniharin* (women bearing water pots), the *purvaj* (ancestor) and *mor* (peacock), geometric motifs, trumpeters, angels, floral forms, the tree of life and animals such as tiger, parrot etc.

Traditionally maroon and black were the colors used, with the surface of the fabric (white) as the third color. Black not only was used as a color but also as the outer linings of the icons and the motifs. Filling in the motifs were sometimes replaced by linear work and pointillist imagery. The color black was meant to repel malevolent spirits and intensify spiritual energy. Contrasts between positive and negative spaces formed an important balancer to the work. Maroon/red was associated with the color of the Mother Earth and believed to possess healing powers. It is the colour of blood, of life, vitality, the colour of the Mother Goddess, the embodiment of power, the nurturer and destroyer… the protector of the weak. White was considered the color for purity and contact with ancestral spirits, deities and other unknown spiritual entities. Gradually other colors from nature started adding to the color palette without having any religious significance. Exposure to a wider palette meant a riot of color and shade in the *Pachedi.*

Technique

- Earlier *khadi* material is replaced today by mill spun grey fabric.
- Before the decoration, the cotton material is first freed of starch by washing and drying in the sun, then it is soaked in a mixture of salt and cow dung and then boiled. Next, it is immersed in water containing caustic soda and castor oil, and then in the base solution (200 grams myrobalan in one gallon of water per 5 kg fabric) for 10 minutes and dried. Now the fabric is ready for painting and printing.
- *Kalam (*sticks*)* cut out of *Baval* tree, were used to draw black lines.
- To quicken the process and meet demands of villagers, who would commission paintings to offer to the mother goddess on fulfillment of wishes, the painters started using mud blocks for printing. These blocks were large and coarse, and after using a few times, would be thrown in the river where they returned to the soil.
- Over the past 50 years, wooden blocks replaced mud blocks, facilitating the use of finer motifs. Used weathered blocks were thrown into the river.

- Many *chitaras* still make the entire painting with the **'***kalam'*, using blocks only for printing the borders. Thus, even today, the artisans make these paintings using the same methods followed 200 years ago.
- The motifs of the *Mata-ni-Pachedi* are printed on with large wooden blocks or painted, using a dye made out of rusted iron which has been soaked for a week in jaggary solution thickened with a flour of tamarind seeds. This reacts with the myrobalan mordant to produce black.
- Most of the spaces between the black printed figures are painted with alum and coloured starch using a *cheed/ baval* stick.
- The shrine cloths are then dyed with alizarin, which reacts with alum to form a deep red. Alizarin is a yellow powder made from the root of madder plant, traditionally used as mordant dye. It produces jet black when applied to iron and a brilliant turkey red where an alum mordant has been used.
- *Dhawda* flowers (200 gm) are added to this alizarin (200gms) bath once it reaches boiling point. This helps maintain the whiteness of the cloth areas which is not printed.
- The painted fabric is boiled in this solution to bring out the colour approximately for an hour while stirring, and then washed.
- Each *Pachedi* after being rinsed by hand is thrown upstream into the shallow waters of the *Sabarmati* river as the cloth must be washed in running water only, so that any excess colour flows away, instead of staining the cloth.
- The *Pachedi* is then bleached and dipped in a bluing agent so that the white areas are fully re-established as brilliant contrast to the red and black painted design.
- It takes days of patience and dedication, to prepare one piece of this beautiful folk art. For instance, painting a cloth of 5' x 9' can take two months.

***Mata-ni-pachedi* today**

With the times changing today, very few craftsmen are willing to continue with the craft. Even the requirement of Mata-ni-Pachedi as an Alter piece has reduced so the *chitaras* are depending on other buyers who buy the pieces for decoration purpose.
The *Chitaras*, who are continuing are also modifying the age old crude craft in the following ways:

- The strong lines and bold use of colour, that reflect the power and energy of the Goddess, have now transformed to more artistic and detailed illustrations; but the depiction style of mythical characters remains the same.
- While earlier imagery always depicted the goddess in the center, modern renditions enjoy a larger degree of artistic freedom.
- The artists now incorporate many more colours such as indigo, green, orange, yellow, grey and pink in the paintings, using the age old methods of extracting colour from natural materials. *Haldi* is used for yellow, *mehndi* for green and indigo for blue.
- The use of screen printing for black outline though rare was also seen.
- They use their skills to make smaller souvenir pieces like wall hangings and stoles, using new motifs for the market.

These changes are required for their survival, but even then the number of *chitaras* is reducing and only a few families are carrying on this 300 year old tradition of painting clothes.

Conclusion

- This art is no longer limited to the shrines, and most of the costly and finer hand-made *Mata-ni-Pachedi's* are purchased by art connoisseurs to be used as decoration for their drawing rooms / offices.
- Creating *Pachedis* as well as new illustrations that are relevant in today's context, but in the same folk style, these craftsmen have remained true to the cause of spreading the glory of the Mother Goddess and her wonderful art.

Each traditional tribal or folk art form in India uses its own technique, process and style which have been handed down through generations. The individual processes can be complex; sometimes the entire family is involved, with each family member responsible for one particular step: doing the outlines, filling in the colour, making the dyes from flowers and minerals. We rarely realize how vital these artists are to the preservation of our country's cultural heritage. Probably if awareness and respect for this art grows, it will help the struggling *chitaras* of *Mata-ni-Pachedi* and encourage the younger generation to continue this great tradition.

References

1. Arch Educational Society (web)
2. *Cloth and Human Experience*. Ed. by. Annette B. Weiner and Jane Schneider. Smithsonian Books: Washington. 1989.
3. Crafts in IndiaI, a premier online handicrafts website
4. Fischer Eberhard, Jyotindra Jain, Haku Shah, *Homage to Kalamkari*, India: Marg Publications 1979
5. Gillow, John and Nicholas Bernard. *Indian Textiles*. London: Thames and Hudson, 2008.
6. Gillow, John and Bryan Sentance. *World Textiles: A Visual Guide to Traditional Techniques*.
7. http://resources.archedu.org/mata_ni_pachedi.html
8. http://www.houseofmg.com/mata-ni-pachedi.htm
9. http://eishasarkar.blogspot.com/2011/02/mata-ni-pachedi.html
10. http://craftofgujarat.com/showpage.aspx?contentid=1015
11. Thames and Hudson: Singapore. 1999.
12. Hacker, Katherine F. *Courtyard, Bazaar, Temple Traditions of Textile Expression in India*.
13. University of Washington Press: Seattle, 1982.
14. Image sourced from Google search engine with the term 'Mata Ni Pachedi'
15. R.ta Kapur Chisti / Rahul Jain *Handcrafted Indian Textiles,* ed by Martand Singh, Roli Books Pvt. Ltd. 2000 Lustre Press Pvt. Ltd.

Shade development and fastness improvement through application of a mixture of natural dyes (Eucalyptus bark and Red Sandalwood) on silk

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Abstract

The study was undertaken with an objective to make the process of natural dyeing cost effective through use of an abundantly and easily available waste product (Eucalyptus bark) and to develop newer, uncommon and darker shades along with improved colour fastness properties through application of mixture of compatible natural dyes. Degummed and aluminium sulphate pre-mordanted crepe silk fabric was dyed using aqueous extract of Eucalyptus bark by the exhaust process. The effect of varying conditions of extraction and dyeing process variables (time, temperature, *p*H, MLR and dye concentration) on surface colour strength and colour related parameters apart from fastness (light, wash, rub and perspiration) was studied and the dyeing condition parameters optimized. Pre-mordanted silk fabric was also dyed with different proportions of the binary mixture of purified extracts of red sandalwood and eucalyptus bark. Compatibility of the mixture of natural dyes was investigated by commonly known conventional methods of compatibility test of dyes and a newer proposed simplified method for comparative and quantitative rating of compatibility to draw a scientific guideline for obtaining good dyeing results for the variety of colours/shades obtained from mixture dyeing. Temperature, *p*H and dye concentration were found to be the predominating dyeing parameters for Eucalyptus bark as indicated by the widely dispersed CDI values. Optimized dyeing conditions for dyeing with aqueous extract of Eucalyptus bark was found to be Time - 60 min, Temp - 80^0C, *p*H – 7, MLR - 1:50 and dye concentration (on the basis of weight % of dried solid eucalyptus bark) – 200%. The colour yield of the purified extract of Eucalyptus bark and red Sandalwood on silk fabrics was found to be higher when the said natural dyes were used in combination than when used alone. Higher *K/S* was obtained with higher proportion of red Sandalwood in the mixture. Both the methods of assessing compatibility of the mixture of dyes, Eucalyptus bark and red Sandalwood i.e. the traditional qualitative method based on plots of *K/S* vs. ΔL and ΔC vs. ΔL and the relatively newer quantitative method based on calculation of closeness of CDI values shows that there is no appreciable synergistic interaction between the two dyes and the RCR was found to be 2. Samples dyed with the mixture of the two dyes showed poor wash fastness with respect to change in the depth of colour, which improved slightly on treatment with CTAB, a cationic dye fixing agent. Thus, the two dyes are only fairly compatible.

***Keywords*:** Cationic dye fixing agent, Eucalyptus bark, Red Sandalwood, Silk.

Ajanta Cave painting and use of natural colours

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Abstract

Today's *Ajanta* Cave is a very famous site of tourist interest and which have been a world heritage site, since 1983. It dates from the 2nd century BC, which are decorated and ornamented with paintings and sculptures. These are considered as the masterpieces of fresco work of Indian art. The execution of this splendid magnificent work took place in two phases, beginning around 200 BC and completing around 600 CE in the canyons of river Waghora of Maharastra state. These huge works however were fortunate to get the proper and requisite patronage of many influential authorities, time to time. The numerous master artists and their followers were involved in this long time project and as a result of which the existence of *Ajanta* made possible. The history of *Ajanta* acknowledges us that it had been abundant and became a forgotten chapter for a long period, and once again opens its veil to the modern day light. In this paper, the caves which are enriched with fresco painting are taken for consideration where the scenes from the life of Lord Buddha, *Jataka* tales and decorative motifs —– geometric and of flora and fauna, both are found. The woven of fresco with lines and shade of colour pigments in *Ajanta* caves is the center of interest in this paper. The authors have made an attempt to high light the intelligent use of natural colours in composing the depicted figurers and motifs on the frescos and the colours which are available in neighboring areas, as well as from distant region.

***Keywords*:** *Ajanta,* Cave painting, Natural colour.

Eco-friendly dyes of India

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Abstract

Industrialisation has made mass production and speedy processes possible. In present days the growth of a country is calculated by how much production they have and how much they are able to sell within the country and mainly abroad, to earn the foreign exchange. The reserve of foreign exchange and gold determines the value of the currency of the country. This has led to an aggressive marketing to create artificial needs of the products especially in the sphere of clothing. Fashion industry is the main product of this artificial need, which encourages people to change the cloths to suit fashion of every season that is every 6 moths! This paper discusses the aspects of Industrialisation; wastages which have led to the environmental issues and what it could further lead to if the measurements are not taken in the right direction. Chemical dye producing and textile industries which use chemical dyes have made the cultivable land barren in various industrial towns and cities. Government prohibition has led to 70 % shut down of the dyeing units in Tiruppur in Tamilnadu. All this leads us to think of alternatives and go back to our age-old techniques in which India excelled for centuries. This paper clears the myths about natural dyes and points out a few natural dyes which help the environment in various ways. It also points at the direction which is more eco-friendly. The issue is more complex than the simple use of natural dyes. It is the thinking and vision which needs to be promoted in the mind of the government, industrialists, dyers as well as the users to solve the environmental issues. This paper shows how traditionally fashion was always a part even without changing the cloths every season!

Keywords**:** Alum, Eco-friendly dyes, Healthy clothing, Healthy dyes, Natural dyes.

Introduction

This paper establishes that the natural dyes could achieve the best colours, best colour fastness is durable, healthy to wear and some also enrich the soil, thus help the environment. However, it points out that the effects of industrialisation and human greed are the main reasons for spoiling the environment. Just using eco-friendly natural dyes does not ensure the return of green earth unless and until we start seeing the problem in totality and determine to solve it leaving personal gains aside, giving priority to the betterment of our earth, the living space for all of us.

Industrialisation and its effect on the environment

Industrialisation has made the mass production and speedy processes possible. Hence the colourful textiles, which were earlier, considered the prized possessions; were able to reach to the poorest. Though the production per say is one of the important factor in counting economic development in the present industrialised world, does it really make life richer? Industrialisation leads to over production, which in turn exhausts the resources at much higher speed than they could be renewed. It creates extravaganza in the minds of people who slowly forget to value the natural resources and take care of it as they are now no more directly connected to the nature, land and the production process. Extra production leads to strong marketing, which has led to consumerism where one keeps buying for the sake of buying. This leads to throwing away things just to buy new ones to be in fashion. The age-old rule of re-using and re-cycling is getting fast forgotten. When people took time to dye the faster colours manually, their skills were excellent. They used lesser chemicals so the disposal of their effluent was less problematic and effluent of some of the natural dyes enriched the soil as mentioned below in this article. Against this, effluents of chemical dyes had made land in the vicinity of Sanganer, a dyeing and printing town of Rajasthan, uncultivable and water un-potable in 1970s and 80s. Presently same is happening in Tiruppur in Tamilnadu, where the farmers created agitation, which led to the shutdown of about 70 % of chemical dyeing units in 2011.

Eco-Friendly Dyes

Before going into the details of eco-friendly dyes it is important to define what could be considered eco-friendly.

"What is Eco-friendly?

Eco-friendly could be defined as

- Any product which does not harm the environment during its process of production, use and after use, meaning at the time of disposal.
- Products that retain or save the environment.
- If they aid the environment it would be better. Such products would be eco-friendly in real term. (Balaram, Eco-Fashions: Trational and Contemporary, 1)

Table 1 lists the products which harm and products which save the environment.

Natural Dyes

There are a few misconceptions which are prevailing about the natural dyes. These are:

- Natural dyes are not as fast as chemical dyes
- Natural dyes give dull colours
- Standardisation of natural dyes is impossible to meet the industries requirements
- All natural dyed fabrics are eco-friendly

Are Natural Dyes really not fast?

To answer this question, let us look at the flourishing trade of Indian textiles which started from the period of Indus civilisation and flourished till the 19th century CE. In the 19th c. CE, apart from industrialisation, the British policies and marketing which discouraged production of Indian textiles and pushed their machine made Lanchaster and Paigely textiles in the world including in India itself to rule the world market and ruin the economic independence of India respectively.

"In the history of world textiles, India was famous for its cotton and its painting, printing and dyeing techniques which yielded varieties of fast colours, while China for its silk production and brocades… Expertise of Indian chintz lay in its fast brilliant multi-coloured exotic patterns, and the quality of the cotton used to paint them, which made them popular all over the world for centuries. Starting from Mohenjodaro period, its demand and praise for its quality continued till 19th century CE, this is for about 6,000 years!" (Balaram, Movement of Textiles and Textile Motifs between India, China, Korea and Japan 2011, 9) As per Narain "Chintzes found in the tombs of the royal patrons of Egypt were nevertheless beautifully coloured and charming. Most of them have been found to be dyed with safflower and indigo which had surely gone from India, the natural home for the indigo plant. That is, at about 4000 B.C. India had been exporting dyestuffs to the countries called cradle of western civilisation." (6) The very fact that the colours of textiles that were found in excavations after several centuries still looked 'beautifully coloured and charming' says a lot about the fastness of the Indian dyes. Strabo the geographer has quoted Nearchos, the admiral of Alexander the Great sent in 327BCE to India "mentions the flower cottons or Chintzes of Indians, and also praises the various beautiful dyes with which their cloths were figured." (qtd. Baker 2). Pliny the Elder (70 CE) described the mordant dyeing process used in Egypt. His description clearly indicates that "the drug employed to stain the cloths were different mordants, which when dyed in a vat of one colour gave various colours on the same cloth from the one dyeing operation." (qtd. Baker 2) Baker comments "Calico printing (or painting) and dyeing therefore were known at this period to the Egyptians, having been doubtlessly acquired from India, and Pliny's writings are the bed-rock from which all knowledge of this nature are derived." (2). These statements confirm that India was expert in mordant dyeing technique, used for dyeing with natural dyes and had exported not only the textiles but also the natural dyes and its dyeing techniques! Japanese scholar Yoshioka Sachio's comment confirms this. He said in 1st century CE, when most of the countries were still at the cradle of civilisation, and could only dye dull browns and gray, India had mastered art of mordant dyeing and was already dyeing fast and brilliant colours, and was exporting their dyed cottons. (Yoshioka 1993)

The best comment is from Cesar de Frederici, the Venetian, who travelled to India in 1563 CE who said that Indian painted cottons extensively traded to Malacca from St. Thomay (Madras) were rare as they looked 'as though they were gilded with diverse colours, and more they are washed the livelier the colours will show." Marco Polo the 13th century Venetian traveller says of the Coromandel especially of Masulipatam, that it is "famous for both muslins and coloured chintzes." (qtd. Baker 19)

In 1980, when the author dyed more than 100 shades of cotton and 100 of silk using natural dyes, she thought of checking the colour fastness of the cotton samples. When the author took these dyed samples to ATIRA (Ahmedabad Textile Industries Research Association) for the colour fastness test the first reaction from ATIRA specialists was these may not stand the fastness tests. They were surprised when natural indigo dyed samples had more than 6 light fastness and they did not do test number 7, as no chemical dyes had ever reached even number 6. Normally fastness number 4 is considered good even for the cotton textiles dyed using chemical dyes in machines. This report proves the point that natural dyes are pretty fast if the dyeing is carried out properly.

Are the colours dull when dyed using natural dyes?

Looking at the brightly coloured textile pieces found at Fustat, which are dated 9th century CE onwards, as well as the trade textiles preserved in all over the world in various museums and private collections, one can easily say that the natural dyes yielded beautiful rich colours. The misconception that natural dyes give dull colours is due to the textiles presently sold as natural dyed fabrics. Many of these present textiles are not dyed completely using natural dyes, for example most of them use alizarin which is manufactured using chemicals. The dyeing process is now shortened and water used is not always as clear as it used to be. These have resulted in dull and not fast colours.

The difference in colour created by using different dyeing methods could easily be understood from the experiment carried out by author at Tokushima in Japan in 1996. To dye silk red, cochineal dye was used along with alum mordant. One piece of silk fabric was dyed using Indian dyeing method while another using Japanese process. The dye, mordant, their quantities, dyeing temperature and duration were all maintained same for both the samples. The silk dyed using Indian method achieved deep and rich red, while the one dyed using Japanese method acquired light pink colour. Thus the brightness of colour is more due to the dyeing process. Hence a sweeping statement that natural dyes yield dull colours is not true.

Standardisation of natural dyes is impossible to meet the industries requirements

This statement raises questions whether natural dyes and manual batch production should try to imitate the quality of chemical dyes and large machine productions of the factories. Instead should it not be the virtue that each individual piece is slightly different than others? Certain amount of quality standardisations could easily be achieved. But there is no harm in having slight difference in colours in production of each batch; actually it makes the fabrics special. Manual production also gives employment and saves energy.

Are all natural dyes and natural dyed fabrics eco-friendly?

During a national conference on Natural Dyes, way back in 1980s, a proud industrialist announced, "Mine is the first industry in India which extracts natural dyes and exports them. Last year I extracted tons of red dye from *sapan*-wood." He also complained that "prices of *sapan*-wood have gone up this year as last year he used up 1/5th of the *sapan* trees of India." The statement shocked the author. If one industry in their greed to earn foreign exchange finishes 1/5th of the trees of a large country as India, what would happen if more industries are opened? Even the same industry had started feeling the shortage of raw material just within a year! This particular tree takes 50 years to grow into a mature tree. Finishing them in 5 years could be so devastating. On asking, "What actions are you taking to replenish the forest? Are you planting new saplings?' The industrialist got very angry and said "It is the duty of the government, of the forest department, if he gets in to planting how *canhe* run his industry?" If we go about using natural dyes in this manner, we would rob the mother earth. The grab-all attitude would only increase the problem rather than solving it. Unless and until we see in totality, there could be no solution.

Another point is the use of chemical mordants such as potassium paramagnet, copper sulphate, which are not eco-friendly and are now banned internationally. Therefore only with the right attitude and use of natural mordants, we can say that natural dyes and natural dyed cloths are eco-friendly.

Healthy Clothing

Most of the natural dyes are extracted from vegetations which are used also as Ayurvedic medicines. Hence some these medicinal properties are transferred to the cloths when they are dyed using these natural dyes. For example, Japanese believe that wearing indigo dyed cloths keep insects away. Hence the Japanese (and Chinese) farmers wore blue cloths dyed using natural indigo to keep mosquitoes, serpents, scorpions away from themselves as they are plentiful in the fields. Due to this insecticides quality indigo dyed towel was used to for the new born babies' first bath. (Balaram, Indigo and Its Use in India 1996)

Possible Cycle of Enriching the Soil

Over the years many times the author faced a statement that "Gandhiji started Satyagraha movement in Champaranya as indigo plantation spoilt the land." Indigo plants cultivated in India were mainly the species of Indigofera. Indigofera are leguminous plants, roots of which deposit nitrogen in the soil. Nitrogen is the main component in fertilizers. Hence even in 1980, when the author had documented the processes of indigo cultivation, extraction of dye and dyeing; the indigo plants after extracting the dye were thrown as green manure in the field for replanting paddy! Indigo was cultivated as a rotational crop with paddy which enriched the soil for the paddy crop (Tolat 1880). Thus if indigo is cultivated as a rotational crop, after extracting the dye even the plant residue could be used leaving no wastage and it also saves land and money by not using chemical fertilizers for paddy.

Eco-Friendly Natural Dyes and Mordants

The most eco-friendly dyes are the ones which could be obtained from flowers, leaves or could be cultivated, as they could be renewed fast, rather than the ones which come from roots or trunk of a tree, for which trees have to be cut. For example, indigo which is extracted from tree, safflower which could be cultivated are eco-friendly dyes while or myrobalan which is a fruit and alum which can be obtained from earth are eco-friendly mordants. Madder roots, *chay* roots and al roots when cultivated could also be eco-friendly but not when an al tree is cut to obtain the dye roots (Balaram, Bastar Textiles 2000).

Conclusion

It is important to use chemical dyes sparingly to save the land and water. Over production leads to the over consumption of raw materials, as well as to the excess waste. Natural resources are limited and cannot be rejuvenated at the speed we are using them up. If we are not careful, we would spoil the mother earth for ever for the generations to come. Natural dyes could reduce the damage from the chemical dyes as well as help in enriching the soil and make our life healthier by wearing such cloths. Even if it is more expensive and laborious it is better to go for it in totality by growing and cultivating such dyes, extracting using natural materials and dyeing using natural mordants.

References

1. Baker, Geo P. *Calico Printing in the East Indies in XVII and XVIIIth Centuries.* London: Edward Arnold, 1921.

2. Balaram, Padmini Tolat. *Bastar Textiles: Designs, Motifs and Natural Dyes.* Bhopal: MPHSVN, 2000.

3. —. "Eco-Fashions: Trational and Contemporary." *Proceedings of the International Seminar on Eco-Fashions.* Thiruppur: NIFTEA Thiruppur, 2011. 1-6.

4. Balaram, Padmini Tolat. "Indigo and Its Use in Japan: A Comparitive Study with India." Japan Foundation Post-Doctoral Fellowship Report, Japan Foundation, Tokyo, 1996.

5. Balaram, Padmini Tolat. "Movement of Textiles and Textile Motifs between India, China, Korea and Japan." PhD Thesis typed manuscript, CEPT University, Ahmedabad, 2011.

6. Narain, Purnendu. *Dyes and Colour Industries in India.* Bombay: Puran Publication, 1946.

7. Tolat, Padmini. "Indigo and Its Use in India." Graduating Thesis, National Institute of Design, Ahmedabad, 1980.

8. Yoshioka, Sachio, ed. *Sarasa, Printed and Painted Textiles.* Kyoto Shoin's Art Library of Japanese Textiles Vol. 20. Kyoto: Kyoto Shoin Co. Ltd., 1993.

Table 1: Products that harm the environment and products that save the Environment (Balaram, Eco-Fashions: Trational and Contemporary, 1)

Which are the Products that Harm the Environment	Which are the Products that Save the Environment?
• Synthetic Dyes	• Natural Dyes
• Synthetic Fibers and Fabrics	• Natural Fibers and Fabrics
• Products that generate excess wastage of material	• Product designed to produce least wastage of materials and recycling waste.
• Processes that consume extra water, fuel, electricity etc.	• Processes which use minimal water and fuel, electricity etc. and re-cycle water.
• Processes that produce harmful gases	• Process which does not produce harmful vapours.
• Throw-away Products	• Re-used, and re-cycled products

Nature — a store house of vegetable dyes

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Abstract

The art of making vegetable dyeing is one of the oldest practices and dates back to the dawn of civilization. In India it was widely used for colouring textiles and other materials from early days. The very earliest dyes were discovered by incidents with the help of berries and fruits. But with the experimentation and gradual development vegetable dyeing have resulted into a highly refined art. India's expertise in vegetable dyeing process dates back since time immemorial using mordanting agents. The discovery of synthetic dyes in 19th century dealt with the massive blow to the Indian textile Industry. Some of the chemical dyes associated with hazards affecting human life creating skin diseases and lung problems, etc. The environmentalists, therefore, started for searching the substitute of synthetic dyes, which has led to the use of more and more natural dyes. In recent days the inherent advantages and use of vegetable dyes has resulted in the revival of the ancient natural colorants. The sources of vegetable dyes are classified as monogenetic and polygenetic. Monogenetic dye produces only one colour on textiles irrespective of mordanting agents, whereas polygenetic dyes develop different colours according to the mordant.

Keywords: Monogenetic, Mordant, Polygenetic, Vegetable dye

Scope of application of Multi-Criteria Decision Making (MCDM) technique for selection of vegetable dye

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Abstract

Multi-criteria decision making is a branch of operation research (OR), now popularly used in the field of engineering, banking, fixing policy matters etc. It can also be applied for taking decisions in daily life like selecting a car for purchase, selecting bride or groom and many others. Various MCDM methods namely Weighted sum model (WSM), Weighted product model (WPM), Analytic Hierarchy Process (AHP), Technique for Order Preference by Similarity to Ideal Solutions (TOPSIS) and Elimination and Choice Translating Reality (ELECTRE) are there to solve many decision making problems, each having its own limitations. However it is very difficult to decide which MCDM method is the best. MCDM methods are prospective quantitative approaches for solving decision problems involving finite number of alternatives and criteria. So the MCDM technique provides enough scope to be applied for the selection of vegetable dye or ranking the dyes among few ones keeping in view a particular object and on the basis of some selection criteria. The present paper is an attempt to explore the scope of applying the AHP method of multi-criteria decision making technique to determine the quality values of selected dyes on the basis of criteria; Fastness properties, economy and toxicity.

Keywords: Analytic Hierarchy Process, Consistency ratio, Vegetable dye.

Introduction

Multiple criteria decision making (MCDM) refers to making decisions in the presence of multiple, usually conflicting, criteria. MCDM problems are common in everyday life. In personal context, a house or a car one buys, may be characterised in terms of price, size, style, safety, comfort, etc. MCDM techniques are very much applicable for selecting students to provide scholarships. In business context, MCDM problems are more complicated and deal with many criteria and sub-criteria to arrive at a decision among many alternatives. Clear understanding on the subject can explore newer fields for its application to make decisions.

Although the selection of vegetable dyes can be made on the basis of experience or some other ways, MCDM technique are yet to find its place for its quality evaluation in more scientific manner. This paper deals with the exploration of possibilities of applying AHP method of MCDM technique for selection of vegetable dye among finite alternatives based on finite number of decision criteria.

Overview of MCDM and AHP

Multiple criteria decision making (MCDM) is a very popular discipline of Operation Research (OR), having relatively short history of about 40 years. Its development has accelerated with the rapid development of computer technology. Computer programming has helped to handle huge data related to criteria, sub-criteria and alternatives, their systematic analysis to tackle MCDM problems, complex in nature. This has made MCDM extremely important and useful tools in solving business decision making problems.

There are many methods available which have enjoyed a wide acceptance in the academic area and many real-world applications. Each of these methods has its own characteristics and background logic. The Weighted sum model (WSM), Weighted product model (WPM), Analytic Hierarchy Process (AHP), Technique for Order Preference by Similarity to Ideal Solutions (TOPSIS) and Elimination and Choice Translating Reality (ELECTRE) are among the most popular ones. Each has some advantages and disadvantages. User has to choice the suitable method according to complexity of the problems. So, it is very difficult to say which one is the best MCDM method.

The Analytic Hierarchy Process (or AHP) method was developed by Professor Thomas Saaty [1-4]. This is one of the frequently discussed methods of decision-making. The reason of its popularity lies in the fact that it can handle the objective as well as subjective factors [5] and the criteria weights and alternative scores are elicited through the formation of a comparison pair-wise matrix which is the heart of the AHP. Since the introduction of AHP, it has evolved into several different variants like revised AHP proposed by Belton and Gear in 1983 [6] and multiplicative AHP proposed by Barzilai and Lootsma in 1994 [7]. These methods have been widely used to solve a broad range of multi-criteria decision problems.

AHP Methodology

AHP decomposes a complex MCDM problem into a system of hierarchy. The final step in AHP deals with the structure of a $m \times n$ matrix. The matrix is constructed by using the relative importance of alternatives in terms of each criterion. The process of working out the problem starts with the formation of a decision hierarchy where the hierarchy of the problem is formed by keeping the overall objective or goal at the top and the alternatives at the bottom. Relevant attributes of the decision problem such as criteria and sub-criteria are placed at the intermediate levels. Next the pair-wise comparison matrix is formed, in this step the relative importance of different criteria with respect to the objective of the problem is determined by using the AHP. For doing this, a pair wise comparison matrix of criteria is constructed using a scale of relative importance proposed by Saaty which is shown in table 2.2. The judgements are entered by using that fundamental scale of AHP. In AHP the number of pair-wise comparisons in a decision problem having m alternatives and n criteria is expressed by the equation;

$$\frac{n(n-1)}{2} + n\frac{m(m-1)}{2}$$

For n criteria, the matrix will be $m \times n$ order. The entry c_{ij} will denote the comparative importance of i criteria with respect to j criteria. In the matrix $c_{ij} = 1$ when $i = j$ and $c_{ji} = \frac{1}{c_{ij}}$.The pair-wise comparison matrix C_1 is shown as: $C_1 = \begin{bmatrix} 1 & c_{12} & ..... & c_{1n} \\ c_{21} & 1 & ..... & c_{2n} \\ ..... & ..... & 1 & ..... \\ c_{n1} & c_{n2} & ..... & 1 \end{bmatrix}$

The normalised weight of the *i-th* criteria (w_i) is determined by calculating the geometric mean of the *i-th* row (GM_i) of the above matrix and then normalising the geometric mean of rows. This can be represented as follows:

$GM_i = \{\prod_{j=1}^{n} c_{ij}\}^{\frac{1}{n}}$ and $w_i = \frac{GM_i}{\sum_{i=1}^{n} GM_i}$

The principal eigen vector (λ_{max}) of the above matrix of the original pair-wise comparison matrix (C_1) is calculated. To check the consistency in pair-wise comparison judgment, consistency index (CI) and consistency ratio (CR) are calculated by following equations:

$$CI = \frac{\lambda_{max} - n}{n-1} \quad \text{and,} \quad CR = \frac{CI}{RCI},$$

Where, *RCI* = random consistency index and its value can be obtained from table 2.3. If the value of CR is 0.1 or less, then the judgment is considered to be consistent and therefore acceptable. Otherwise the decision maker has to reconsider the entries pair-wise comparison matrix.

In order to calculate the relative importance of sub criteria with respect to corresponding criteria, the pair-wise comparison between the attributes of sub-criteria are made in the same way previously discussed. The global weights of sub-criteria are calculated by multiplying the relative weight of sub-criteria with respect to the corresponding criterion and the relative weight of criterion with respect to the objective.

Table 1: The fundamental relational scale for pair-wise comparisons proposed by Saaty [1]

Intensity of importance on an absolute scale	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective.
3	Moderate importance of one over another	Experience and judgment slightly favour one activity over another.
5	Essential or strong importance	Experience and judgment strongly favour one activity over another
7	Very strong importance	An activity is strongly favoured and its dominance is demonstrated in practice.
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values between two adjacent judgment	When compromise is needed.
Reciprocal	If activity p has one of the above numbers assigned to it when compared with activity q, then q has the reciprocal value when compared with p	

After obtaining the global weights of each attributes, the priority index is calculated according to the variant of AHP followed. Finally the ranking of the alternatives are made on the basis of index obtained

Table 2: RCI values of different number of alternatives

M	1	2	3	4	5	6	7	8	9
RCI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45

Some application of MCDM techniques in textiles

Some published research works have been reported in the area of textiles manufacture. Majumdar A et al. [8] in their work has selected a suitable navel out of ten navels for denim fabrics using a combination of two popular MCDM approaches namely, technique for order preference by similarity to ideal solutions (TOPSIS) and analytic hierarchy process (AHP). Ranking of navels was elicited in accordance with the relative closeness value determined by TOPSIS method. For the determination of technological value of cotton fibre Majumdar A et al. [5] have used Multi-criteria decision- making approach and compared its efficacy with existing approach. The MCDM approach was found to give better correlation between fibre quality and yarn strength. Hybrid AHP-TOPSIS method of Multi-criteria decision-making was also found to be effective as shown by Majumdar et al. [9] in their study for ranking the cotton fibres which gave good agreement with the ranking of yarn in terms of tenacity.

Application of Miltiplicative AHP in section of vegetable dyes

Hierarchy formulation

The goal or objective of the present investigation is to determine the acceptance value of vegetable dyes which should reflect the achievable level of Fastness properties, availability and polygenetic properties. So, the dye properties criteria of this problem can be classified under three headings, namely fastness properties, cost and polygenetic properties. Fastness properties can be divided into three sub-criteria, washing fastness (WF), rubbing fastness (RF) and light fastness (LF) whereas cost criteria and polygenetic properties are solely represented by raw material cost (RMC) and no. of available shades (NAS) respectively.

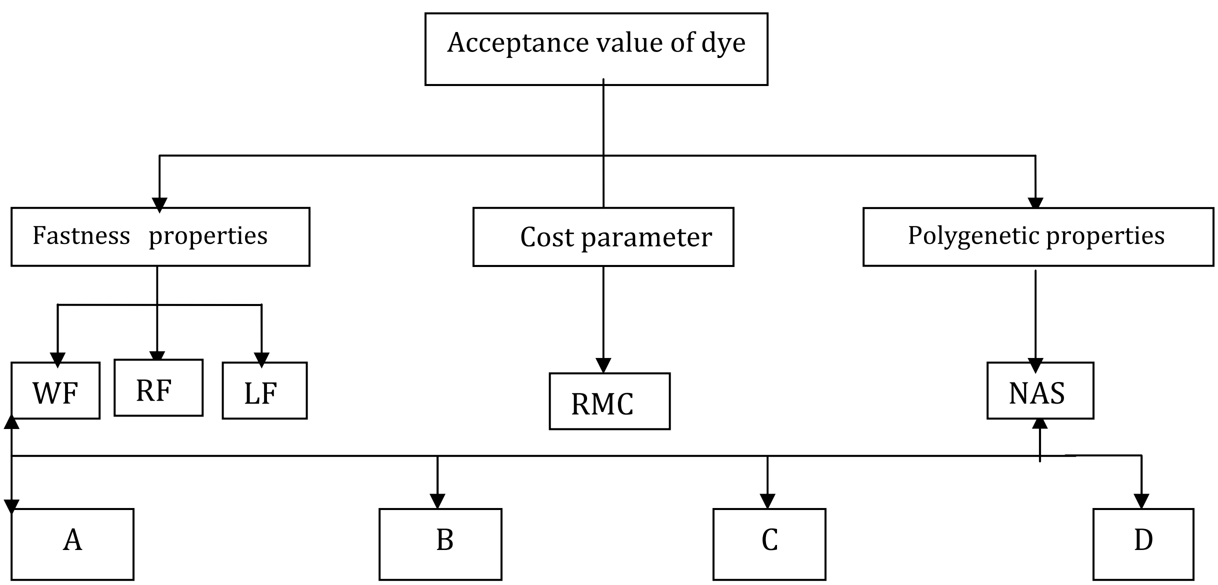

Fig. 1: Hierarchical structure of dye properties

At the lowest level of the hierarchy, there are three alternatives of dye types namely A, B and C which should be ranked according to their acceptance value. The schematic representation of the problem is depicted in Fig. 1.

Determination of criteria weights and rankings of alternatives

With respect of the objective of the problem, the pair-wise comparison matrix of three criteria is given in table 3. Here the comparison is made according to Saaty's scale given in Table 1.

Table 3: Pair-wise comparison matrix of criteria with respect to objective

Criteria	Fastness	Cost	Shade variation	Geometric Mean(GM)	Normalized GM
Fastness	1	7	5	3.271	0.731
Cost	1/7	1	1/3	0.362	0.081
Polygenetic properties	1/5	3	1	0.843	0.188

It can be inferred from table 3 that fastness properties very strongly predominate over the cost parameter and essentially predominate over polygenetic properties whereas the dominance of polygenetic properties over cost parameter is moderate. The normalized GM column of table 3 indicates that the fastness properties of dye have the most dominant influence with a relative weight of 0.730. The relative weights of cost and polygenetic properties are 0.080 and 0.188 respectively. For the measurement of consistency of judgment, the original matrix is multiplied by the weight vector to obtain the product as shown below:

$$\begin{bmatrix} 1 & 7 & 5 \\ 1/7 & 1 & 1/3 \\ 1/5 & 3 & 1 \end{bmatrix} \times \begin{bmatrix} 0.731 \\ 0.081 \\ 0.188 \end{bmatrix} = \begin{bmatrix} 2.230 \\ 0.247 \\ 0.574 \end{bmatrix}$$

Now, $\lambda max = (\frac{2.230}{0.731} + \frac{0.247}{0.081} + \frac{0.574}{0.188})/3$ = 3.065

The consistency in the pair-wise judgment is found to be justified as confirmed from calculating the consistency index (CI) and consistency ratio (CR) putting the value of random consistency index (RCI) against corresponding number of alternatives from Table 2.

Therefore, $CI = \frac{3.065-3}{3-1} = 0.0325$ & $CR = \frac{CI}{RCI} = \frac{0.0325}{0.58} = 0.056 < 0.1$(acceptable)

In order to calculate the relative weights of sub criteria with respect to corresponding criteria, the pair-wise comparison between sub-criteria of fastness properties and the derived weight vectors are shown in Table 4. Then the global weights of sub-criteria are calculated by multiplying the relative weight of sub-criteria with respect to the corresponding criterion and the relative weight of criterion with respect to the objective. Hence, the global weight of washing fastness is 0.538×0.731=0.393, the global weight of rubbing fastness is 0.164×0.731=0.119, and the global weight of light fastness is 0.298×0.731=0.218.

The global weight of cost parameter and polygenic properties are 0.081 and 0.188 respectively.

Table 4: Pair-wise comparison of sub-criteria with respect to fastness properties

Tensile properties	Washing fastness	Rubbing fastness	Light fastness	GM	Normalised GM
Washing fastness	1	3	2	1.817	0.538
Rubbing fastness	1/3	1	1/2	0.550	0.164
Light fastness	1/2	2	1	1	0.298

$CR - 0.012$

Therefore, according to the multiplicative AHP model, the equation to calculate the acceptance value of yarns (MI_{AHP}) becomes:

$$MI_{AHP} = \frac{WF^{0.395} RF^{0.110} LF^{0.218} NAS^{0.188}}{RMC^{0.081}}$$

The values of MI_{AHP} for A, B, C & D type of vegetable dyes can be calculated on the basis of actual values of parameters against corresponding dye type. The dye having highest MI_{AHP} value will rank top and is most acceptable. The descending order in the values will be the ranking on priority.

Conclusions

Hence, it can be concluded that the selection of natural dyes can effectively be made using multiplicative AHP technique very well. The selection is never made on the basis of sole criteria of fastness or other but on the basis of considering three criteria altogether.

References

1. Saaty T L, *The Analytic Hierarchy Process,* Mcgraw-Hill International, New York (1980).
2. Saaty T L, *European J. of Operational Res.*, 48 (1990) 9-26.
3. Vaidya O S and Kumar S, *European J. of Operational Res.*, 169 (2006) 1-29.
4. Saaty T L, *European J. of Operational Res.*, 32 (7) (1983) 841-855.
5. Majumdar A, Majumdar P K and Sarkar B, *AUTEX Res. J,* 5(2) (2005) 71-80.
6. Belton V. and Gear A E, (1983), "On a shortcoming of Saaty's method of analytic hierarchies," *Omega*, Vol.13, pp.143-144.
7. Barzilai J, and Lootsma F A, Forman EH (ed.), "Power Relations and Group Aggregation in the Multiplicative AHP and SMART," *Proceedings of the Third International Symposium on the AHP*, George Washington University, Washington, DC, U.S.A. (1994) 157-168.
8. Majumdar A, Kaplan S and GoKtepe O, *J text. Ins* 101 (4) 2010, 304-309.
9. Majumdar A, Sarkar B and Majumdar P K, *J text. Ins* 96 (5) 2005, 303-309.

DABU - A unique style of mud printing

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Abstract

Rajasthan is known for their eye-catching multicolor dressings, which are produced by unique dyeing and printing techniques with vegetable colours, mostly on cotton fabric. The present article deals with some of the oldest techniques of dyeing and printing. The art of printing was patronized by the Royals in Rajasthan. They played key role in the survival and development of printing and still there were many centers deprived of Royal patronage. These centers practiced the folk form of printing commonly known as "DABU". It is one of the oldest printing techniques in India. And is the most popular and favoured printing of Rajasthan. *Dabu* is a resist print technique, which implies covering or impregnating of certain portions of the cloth, intended to be kept in the background colour. This covering is done with wax, clay, gum, resin or other resisting materials. Dabu was popular in all those centers of Rajasthan, where there was abundance of water. In Bagru near Jaipur, Barmer and kaladera near Udaipur, Jodhpur, Akola near Chittorgarh etc. this technique is practiced with few changes and modification in the material, ingredients, colour scheme and motifs. *Kalidar Dabu*, *dolidar dabu* and *gwar wali dabu* are the most popular *Dabu* in Rajasthan.

Keywords: Dabu, Multicolour, Natural dye, Resist.

Introduction

Rajasthan is known for its eye-catching, multicolor dressing, which is produced by unique dyeing and printing techniques with vegetable colours, mostly on cotton fabric. We find conservation of some of the oldest technique of dyeing and printing here.

The art of printing was patronized by the Royals in Rajasthan. They played important role in the survival and development of printing. Still there were many centers deprived of Royal patronage. These centers practiced the folk form of printing commonly known as "*DABU*".[1] It is one of the oldest printing techniques in India. Though many printing techniques are used in this region, "*DABU*" is the most popular and favored printing of Rajasthan.

Dabu was developed centuries before the mughals invaded India[2] and is originally an Indian printing technique. Although we don't get much physical proof, as the clothes did not last due to adverse atmospheric condition in Rajasthan. Enquiries with artists reveal that they are practicing this technique since generations. An 8th century sample of *Dabu* found in Central Asia is believed to be printed in India. Apart from this, literatures of medieval age have words like, *"Uchcho"* [3] (print industry) and *"Champai"* [4] (chippa or printer) in them.

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[1]. **Daveki Ahiwasi**,:"Range Avem Chhappe Vastra", 1976, pg 21

[2]. Ibid., p-22

[3]. **Gopal gee Lallan**,"The Economic Life of Northern India",Lesson-4,1965,pg-12

[4]. **Moti Chandra**,"General of Indian Textile History", part -5,pg.23

Which substantiate the claim of *Dabu* not only being of Indian origin, but also one of its oldest printing techniques.

Dabu is a resist print technique. This implies covering or impregnating of certain portions of the cloth, intended to be kept in the background colour. This covering is done with wax, clay, Gum, Resin or other resist. Because of this, when the cloth is subsequently dyed, the colour does not penetrate the portions impregnated with resist. Through this process, desired pattern is obtained. [5]

Dabu was popular in all those centers of Rajasthan, where there was abundance of water. Bagru near Jaipur, Barmer and kaladera near Udaipur, Jodhpur, Akola near Chittorgarh etc. are centers where the technique is practiced with few changes in the material, ingredients, colour scheme and motifs.

Types of Dabu

Kalidar Dabu, *dolidar dabu* and *gwar wali dabu* are the most popular *Dabu* in Rajasthan [6].

***Kalidar* Dabu**

Five kg of *kali mitti* (clay) is kept in around half a litre of water for a night. Next day this water soaked mud is kept on a plain surface stone or floor. Nearly half kg of finally stained *chuna* (Calcium hydroxide) and one kg of *beedan* (moth-eaten wheat flour) is added to this mud. Then this whole material is mixed with trading of feet. *Gond* (gum) solution is periodically added to it to make this mixture adhesively strong. This whole process ends in thirty minutes. Thus obtained mixture is again kept for a night. Next day it is stained with fine muslin cloth to discard rough particles. This final solution is kept in a mud pot popularly known as '*Mardia*'. The mud resist is freshly prepared before every printing.

Dolidar Dabu

An appropriate amount of *gond*, *chuna* and *multani mitti* is mixed separately in water and kept separately in vessels. Next morning the solution of *gond* and *chuna* are mixed properly and then required amount of multani *mitti* is added in it to make this mixture thicker. This mixture is stained with fine muslin cloth to discard rough particles. This solution too is kept in a "*mardia*".

Gawarvali *Dabu*

The 2kg of *gwar (a bean vegetable) is* roasted till they get brown. Then they are ground to fine powder. An amount of *chuna* is boiled and then stained fine to mix it with *gwar* powder. This mixture is dried and then again ground to make it fine. This is finally mixed with a solution of gum. This solution is made thick or thin according to the need.

5.Indian printed Textiles, All India Handicrafts Board, Government of India,pg-3

6. Vandana Bhandari;"Costumes,Textiles & Jewellery of India",2004.pg-48

Mein ki Dabu

Apart from *mitti dabu*, another technique called "*mein ki dabu*" – wax resist was also popular in Rajasthan. Cloths printed with this technique were used to give out a smell of perfume. For this, nearly two and a half kg of honeybee wax, 10kg of *chir* (pine) solution and an amount of *Tilli* oil mixed with small quantity of pure ghee was heated on a certain temperature. The solution obtained was stained directly in '*mardia'* (mud pot). Whenever there was a need, this solution was again heated to use. The impression of cracks is equal and clear in this *dabu* in comparison with *mitti dabu*, where the cracks are arbitrary and not in control. The process of taking off this *dabu* from the fabric is known as *Ukala*. The process is done by adding 5% of soda ash in hot water.

Role of ingredients

Interestingly all the three essential ingredients play different roles. While the *chuna or lime* is used to thicken solution. The *mitti* or *clay* holds the ingredients together; *gond or gum* helps in washing away the resist paste after the final dyeing is done[7]. Different kind of mud play different role in this printing. *Kirana or chuna* (lime) is weakest resist and is used for fine outline. *Mitti* (clay) is used when the cloths needs to be immersed in indigo for few times. *Rait* (sand), the storages of the mud resist is used for extremely absorbent pomegranate and ferrous dyes. [8]

Dabu process

The process of *dabu* printing begins with washing and desizing the fabric. The chosen fabric is washed thoroughly to remove all starch and then dried. Now the fabric is treated with *harda* powder; the mordant, and then dried again. It is then printed with the *syahi* and begar paste in two distinct steps.

Dabu Blocks

Wooden blocks are the main printing tools of *Rajasthani* printing. They are prepared by the local carpenters, locally called '*batkare'* or one who can give shape to things. These blocks are generally half an inch deep and usually made of *gurjan*, *shisham*, teakwood or *rohira* wood. There are three types of blocks, named - *gad*, *rekh* and *data.* D*abu* is applied on the cloth using a *datta* block mostly. The *dabu* blocks should be of the same precision as that of the main *butis*. Both are of same types. The *dabu* printing is done on a single table while sitting or on a running table. This depends on the availability of space and comfort of the printer.

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7. **Gulab Kothari**,"Rajasthan ki Bahurangi Vastra Parampara",pg-4
8. **Aditi Ranjan & M.P. Ranjan,** "Crafts of India,Handmade in India",2007,pg-122

Application of *dabu* on fabric

Instead of printing the fabric with block, the dabu is spread with a brush, when original background colour of the fabric is not to be disturbed. *Dabu* process is sequencing of different stages of dyeing & printing, which vary depending on the desired final pattern.

The areas with *dabu* resist will not absorb colour on further dyeing. Saw dust is sprinkled over the surface, following the application of *dabu* to facilitate quick drying of the fabric. The saw dust also acts as a binder which prevents color penetration while dyeing. Dying with alizarin develops a rich red colour in areas printed with *begar* paste. The fabric is then washed & dried and if needed, printed again with *dabu* before immersing in *neel o*r indigo dye to produce a deep blue colour. Before executing another work of *dabu*, the cloth must be dried properly first; otherwise the colours will spill over on a wet ground. It is therefore, that *dabu* work is not done during the rainy season.

After the application of *dabu*, the cloth is dyed in blue. *neel* or indigo. The blue dye is frequently used in the region. It is extracted from the *neel* plant (indigofera tinctoria). For blue dye, the cloth is soaked in a nine feet deep *maat* (pitcher) for 15 to 20 minutes and then taken out. It is quickly dried by two people holding the cloth lengthwise and blowing it in the wind. Then it is soaked once more. After each dip and airing more *dabu* pattern can be applied giving a full range of blue shades. This process is repeated half a dozen times. The cloth is spread out in the sun after it has been immersed in Indigo. Before drying, the fabric is rinsed in flowing water to wash the *Dabu*. Motifs printed in light colours with *Dabu* on colourful backround of the fabric gives a beautiful impression. In another process of *Dabu*, application of mud resist onto the fabric is followed by dyeing the fabric in a cauldron of dye. The process may be repeated for double *Dabu* and triple *Dabu* and hence forth. After every dyeing the fabric is thoroughly washed so as to remove the mud application. Finally, the non-dyed part where the resist has been applied is revealed after the washing.

Use of *Dabu* in designs

Traditionally, *Dabu* is used to keep the printed or background portion white. It is used in different styles in *bhant* (design).

Tor datai: Here *dabu* is used on the *rekh* (outline) printed with *syahi* in the *bhant* (design).Through this we obtain coloured design, while the cloth surface remains as it is.

Podh datai: There is not much difference in *tor datai* and *podh datai***.** *Podh Datai* **(**chappai**)** is done by *Dabu* on different parts of design, such as leaves or stem and then couloured with neel or some other vegetable colours. Through this we obtain coloured background, while the colour of design remains as it is.

Rata datai: Here *Dabu* printing is done on some designs after colouring with *syahi* or *beggar*∗.

Dabu and communities

We see that *chhippa* community of traditional printers of *dabu* use the mud resist technique with vegetable dyes to create densely patterned and rich coloured textiles. That caters to the functional and sartorial requirement of many local communities, such as the *Patel*, *Meghwal*, *Sindhi*, *Muslims*, *Mali*, *Raika*, *Rabari*, *Jat*, *Bishnois* etc. Although all the motifs are derived from vegetable and floral forms, each bears a unique association with a specific community, thus serving as a mean of identifying the community of the wearer.

Conclusion

Like many other traditional arts, *Dabu* almost lost its relevance in the new era of modern printing. It became a time consuming process with less profit. Many *Chippas* opted to the easy practice of new trend in art & craft. But some of the traditional *Chippas* tried to keep this art alive by making few changes according to the demand of modern time buyers. The Government of Rajasthan also promoted and supported them in this cause. Since last few years some new experiments are being done with *Dabu* printing, designs and dyeing. Printers are using different minerals and vegetable colours to enhance the *Dabu* print. These efforts are giving result now and *Dabu* is regaining its lost Glory. But still it is a long journey for this beautiful art.

Appendix

[*] *Syahi- beggar* – ***Syahi*** means 'black ink'.The *syahi* printing past is prepared by *kaccha loha* (raw iron), *Gur* (jagarry) and water.The *syahi* is mostly used for **rekh** outline.
Beggar, a mordant used for 'red colour'.It is prepared out *fitkari* (alum), *garu* (iron oxide) and local tree gum with water.The red colour mostly used for **gadh** filling of the space and **dutta** infill block to areas of the design.

References

1. Daveki Ahiwasi,:"Range Avem Chhappe Vastra", 1976, pg 21
2. Ibid., p-22
3. Gopal gee Lallan,"The Economic Life of Northen India", Lesson-4, 1965, pg-12
4. Moti Chandra,"General of Indian Textile History", part -5, pg.23
5. Indian Printed Textiles, All India Handicrafts Board, Government of India, pg-3
6. Vandana Bhandari,"Costumes,Textiles & jewelleryn of India",2004.pg-48
7. Gulab Kothari,Rajusthan ki Bahurangi Vastra Parampara,pg-4
8. Aditi Ranjan & M.P. Ranjan," Crafts of India, Handmade in India",2007,pg-122

DABU Printed Cloths

Variations of *DABU* Designs produced using with different mineral and vegetables dyes.

DABU Process

Preparation of *Dabu* Paste (mud *Dabu*)

Printing with Dabu & printed cloth

Indigo dyeing & sun dry of dye cloth after printing

Mordants and their hazards

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Abstract

There is a popular opinion that 'natural' means completely safe and ecofriendly. Contrary to this opinion, natural dyes are often neither safer nor more ecologically sound than synthetic dyes. Life Cycle Assessment (LCA), which is a method to study the environmental aspects and potential impacts throughout the product's life (i.e. 'cradle-to-grave'), is essential before making any concrete comment regarding eco-friendliness of any product or process. Unmodified natural dyes, in general, may have a significantly lower environmental impact, however. This article reveals that most natural dyes are not particularly toxic in themselves, but they will not stick to textile fibres unless they are treated with a mordant. Mordants that are commonly used by "natural" dyers today are metal salts, which vary from slightly to deadly poisonous. Typically, a mordant is a heavy metal. Heavy metals are extremely toxic, and bad for the environment, as well. Amidst all the mordants employed for natural dyeing purposes, alum is relatively safe, and in the interest of sustainability and lower environmental impact, all others could be eliminated.

Keywords: Environmental impact, Heavy metals, Mordants, Natural dyes, Toxicity.

Introduction

Today, natural colourants that are safer and ecofriendly in nature [2] are emerging globally, leaving synthetic colourants behind in the race. These have been used for textiles for a long time. Natural dyes exhibit better biodegradability and are generally more compatible with the environment. In spite of their inferior fastness, natural dyes are more acceptable to environmentally conscious people around the world [3].

In response to the "green" movement and ecological campaigns, some dye manufacturers might be re-considering the feasibility of adopting natural dye in lieu of synthetic dye in dyeing process. Since the adoption of natural dyes may lead to the problems of poor dye uptake and low colour fastness, it is quite logical for them to introduce a traditional mordant to resolve the situation. In common practice, the traditional mordants adopted fall mainly within the group of heavy metal category. The heavy metals detached from these traditional mordants, however, will contaminate the water and poison the environment, thereby jeopardising the original intention of using environmentally friendly dye for better protection of the environment [3].

Contrary to popular opinion, natural dyes are often neither safer nor more ecologically sound than synthetic dyes. They are less permanent, more difficult to apply, wash out more easily, and often involve the use of highly toxic mordants. Some natural dyes, such as the hematein derived from logwood, are themselves significantly poisonous. Of course, the color possibilities are far more limited; the color of any natural dye may be easily copied by mixing synthetic dyes, but many other colors are not easily obtained with natural dyes. However, some mordants are not very toxic, and the idea of natural dyestuffs is aesthetically pleasing [4].

Most natural dyeing is done with the use of mordants, most commonly heavy metal ions, but sometimes tannins. Tannins are particularly important in dyeing cotton and other cellulose fibers. The mordant allows many natural dyes which would otherwise just wash out to attain acceptable wash fastness. A mordant remains in the fiber permanently, holding the dye. Each different metal used as a mordant produces a different range of colors for each dye.

What is Mordant?

A mordant is a substance used to set/fix dyes on fabrics or tissue sections by forming a coordination complex with the dye which then attaches to the fabric or tissue of animals and plants [5]. It may be used for dyeing fabrics, or for intensifying stains in cell or tissue preparations. The term mordant comes from the Latin word, "mordere", meaning, to bite. In the past, it was thought that a mordant helped the dye bite onto the fiber so that it would hold fast during washing. A mordant is often a polyvalent metal ion [6, 7] used to cause fibres to open up and receive colouration by absorbing ——— and absorbing the dye acids present in the plants [8]. The resulting coordination complex of dye and ion is colloidal and can be either acidic or alkaline. A mordant does not serve as a colour source of its own.

Common mordants for natural colour dyeing

Historically, stale urine was used a lot as a mordant. It is strongly alkali and also affects the final colour of several dyes. It is still a good one to use but not many people like working with it these days [9].

Commonly used mordants for natural colour dyeing include tannic acid, alum, urine, chrome alum, sodium chloride, and certain salts of aluminium, chromium, copper, iron, iodine, potassium, sodium, and tin.

Containers other than glass or stainless steel may also be used, and the metals from which they are made may be employed to exert an influence on the ultimate color of the dye in the form of a mordant [10].

Mordants which are generally employed for the natural dyeing purposes are commercially available, commonly in the form of salts from metals such as tin, chrome, iron, copper, and aluminum. These mordants in descending order of relative toxicity are listed as follows: chrome, tin, iron, copper, and aluminum [10].

Alum (Aluminum Potassium Sulfate)

This is the most widely used mordant. Be careful not to use too much with wool, otherwise you will get a sticky feeling that doesn't come out.

Copper (Copper Sulfate)

This mordant is used to bring out the greens in dyes. It will also darken the dye colors, similar to using tin, but is less harsh.

Chrome (Potassium Dichromate)

Chrome brightens the dye colors and is more commonly used with wool and mohair than with any other fiber.

Iron (Ferrous Sulfate)

It dulls and darkens the dye colours. Using too much of this mordant will make the fiber brittle.

Glaubersalt (Sodium Sulfate)

It is used during natural dyeing to level out the bath. It is also used in chemical dye.

Spectralite (Thiourea Dioxide)

This is a reducing agent for indigo dyeing.

Tara Powder (Caesalpinia Spinosa)

Tara Powder is a natural tannin product. It is needed for darker colors on cotton, linen and hemp.

Tartaric Acid

This is a must for cochineal. This mordant will expand the cochineal colors.

Tin (Stannous Chloride)

Tin will give extra bright colors to reds, oranges and yellows on protein fibers. Using too much will make wool and silk brittle. To avoid this, a pinch of tin can be added at the end of the dyeing time with fiber that was premordanted with alum. Tin is not commonly used with cellulosic fibers.

Calcium Carbonate

It is generally used with indigo powder for the Saxon blue color. It can also be used to lower the acidity of a dyebath.

Methods of applying mordants

There are three methods by which mordanting can be done:

- Pre-mordanting (onchrome): The substrate is treated with the mordant and then dyed.

- Meta-mordanting (metachrome): The mordant is added in the dye bath itself.
- Post-mordanting (afterchrome): The dyed material is treated with a mordant.

The type of mordant used changes the shade obtained after dyeing and also affects the fastness property of the dye. The application of mordant, either pre-, meta- or post-mordant methods, is influenced by:

- The action of the mordant on the substrate: if the mordant and dye methods are harsh (e.g. an acidic mordant with an acidic dye), pre- or post-mordanting limits the potential for damage to the substrate.
- The stability of the mordant and/or dye lake: the formation of a stable dye lake means that the mordant can be added in the dye without risk of losing the dye properties (meta-mordanting).

Dye results can also rely on the mordant chosen as the introduction of the mordant into the dye will have a marked effect on the final color. Each dye can have different reactions to each mordant.

The dye lake is an insoluble molecule formed when the complex of dye and mordant are combined, which then attaches to the substrate. Mordants increase the fastness of the dye since the larger molecule is now bonded to the fiber. The type of mordant used can change the colour of both the dye-plus-mordant solution and influence the shade of the final product [5, 6].

Dangers of mordants

Most natural dyes are not particularly toxic in themselves, but they will not stick to fabric unless a mordant is used. Mordants that are commonly used by "natural" dyers today are metal salts, which vary from slightly to deadly poisonous. Typically, a mordant is a heavy metal. Heavy metals are extremely toxic, and bad for the environment, as well.

Most recently, the term "heavy metal" has been used as a general term for those metals and semimetals with potential human or environmental toxicity. This definition includes a broad section of the periodic table under the rubric of interest. If unrecognized or inappropriately treated, heavy metal exposure can result in significant morbidity and mortality. [11].

Alum is a relatively safe mordant that is often used with natural dyes. It is any of several chemical compounds based on aluminum, which (in spite of the silly claims about Alzheimer's disease, which is not caused by aluminum) is much safer than chromium and other heavy metals. However, even alum has been known to kill people! The fatal dose of alum is 30 grams for an adult; the fatal dose for a small child is, of course, far less, depending on body weight, perhaps as little as 3 grams. Doses that are too low to kill may still cause irritation or more serious health problems. We should never be misled by descriptions of "food grade alum". The fact that tiny amounts of alum are used in pickles which are intended to be eaten in small quantities does not show that alum is safe in dye-use quantities. All mordants should always be kept well out of the reach of children. Alum can be used safely as long as small children or others who might be inclined to eat the materials are not present, and if the material mordanted with alum is not given to babies or others who might chew on the fabric. Alum is the most popular mordant; though less toxic than the other metal ions, it is an irritant, and may be harmful if ingested [1]. The potash alum used by dyers is also considered mildly poisonous [6].

Somewhat more dangerous mordants are copper (Cuprous sulphate) and iron (ferrous sulphate). Either can be deadly, and should not be used around children, but they are safe to use if all of the required safety precautions/measures are followed. Iron is toxic in overdose (according to the United States FDA, iron is the leading cause of poisoning deaths in children under 6, despite child-resistant packaging), but it will not harm the environment when disposed of. Iron is not only a mordant for other dyes, but can be used as an interesting dye in its own right, by applying bits of iron metal to fabric and allowing them to rust. At least it does not poison the ground if this mordant is poured out on it [12-14].

Chrome (Potassium di- or bi-chromate) mordant, in contrast, will poison the ground, and it has caused many serious injuries or deaths among workers exposed to it. It is extremely toxic in nature. It is a known human carcinogen. Chrome can produce very bright yellows, but it is not worth the risk of cancer, other illnesses, and even death. Chrome should not be inhaled, and gloves should be worn while working with chrome. Left over mordant water should be disposed of at a chemical waste disposal site and treated as hazardous waste [12-14].

Tin mordant is not recommended for beginning dyers, but can be used with care. It is extremely toxic [1]. Even copper and iron mordants can be quite dangerous if misused. (Iron is nutritionally necessary, but iron pills are a major cause of accidental poisoning deaths among children.) [1]. Copper and Chrome have been redlisted, according to eco-standards, in terms of toxicity [7], and the powders of these two metals, as well as tin, can be deadly when consumed or inhaled.

Table 1 and 2 shows the health hazards or ailments caused by some of the common mordants which are used for natural dyeing.

Measures to mitigate hazards of mordants

There are ways to use these mordants, however, without endangering the environment with toxic wastewaters or endangering dyers with toxic fumes or powders [4]. When using commercially prepared mordants care should be taken of how we use, store, and dispose of them. It should be remembered that many of them are toxic, especially if allowed to build up over a period of time [10]. To mordant with tin or copper, the natural dyer can acquire a used tin or copper pot to boil the fiber (and the dye yielding plants). Aluminum and cast iron pots, likewise, work in this capacity. Copper pennies or tubing can be added to a mordant bath. A handful of rusty nails, when boiled with a fiber, acts as an iron mordant. Potash alum (Aluminum potassium sulphate) is not the only alum that will mordant a fiber; pickling alum (Aluminum ammonium sulfate), which can be found in pharmacies and grocery stores, will also work, with even more yellowing effect [5]. Pickling alum is considered safe enough to eat, and a spent mordant bath can be discarded in the sink, added to the compost, or fed to plants that require acidity in the soil. Cream of tartar, another food additive, can be used in conjunction with alum, to soften the wool (alum can cause fibers to become brittle). Copperas (Ferrous sulfate) is used to acidify soils. For most plants soil acidification is unnecessary, but lowering the soil pH is frequently required to grow plants such as blueberries, azaleas, and rhododendrons successfully [8]. Copperas powder can be used as an iron mordant, although it is not as safe as pickling alum. If copperas is used, it is better not to inhale the fumes, but the exhausted mordant water can be fed to the lawn, the compost or acid loving plants without any hesitation. Of all the mordants mentioned, alum is the most commonly used, and in the interest of sustainability, all others could be eliminated [4].

Conclusion

Natural dyes are rarely low-impact, depending on the specific dye and mordant used. Unmodified natural dyes may have a significantly lower environmental impact. Mordants (the substance used to "fix" the color onto the fabric) such as chromium and copper are very toxic and high impact. The large quantities of natural dyestuffs required for dyeing, typically equal to or double that of the fiber's own weight, make natural dyes prepared from wild plants and lichens very high impact. We should never assume that 'natural' means safe. Toxicology of successful natural dyes needs to be researched extensively and any chemical modification of the dyes may require new toxicology testing. Life Cycle Assessment (LCA) is essential to make any definite comment regarding eco-friendliness and environmental impact of the natural dyes, the associated dye mordants and the dyeing process. When using natural dyes, we should be careful enough to research the safety of the dyes and mordants. Of the handful of mordants used during natural colour dyeing, alum is relatively safe and low impact, but that too should be used very cautiously taking recommended dose during dyeing.

Reference

1. Kumar, J.K. and Sinha, A.K. 2004. Resurgence of natural colourants. Natural Product Res.
   18:59-84
2. Deo, H.T. and Desai, b.K. 1999. Dyeing of cotton and jute with tea as natural dye. J. Soc. Dyers Col.115:224-227
3. Chan, P.M., Yuen, C.W.M., and Yeung, K.W., The Effect of Natural Dye effluent on the Environment, RJTA, Vol.6, No. 1, 57.
4. URL: http://www.pburch.net/
5. IUPAC, *Compendium of Chemical Terminology*, 2nd ed. (the "Gold Book") (1997). Online corrected version: (1993) "mordant".
6. URL: http://en.wikipedia.org/wiki/Mordant
7. Llewellyn, Bryan D., May, 2005. "Stain Theory – How mordants work".
8. Bliss, Anne. North American Dye Plants. Loveland, CO: Interweave Press, 1993.
9. URL: http://www.downsizer.net
10. MarshalJ,Worksin Fabric: Mordants, URL: http://www.johnmarshall.to/index.htm

11. Soghoian S., Heavy Metal Toxicity, Medscape Reference, URL: http://reference.medscape.com/
12. Casselmen, Karen Leigh. Craft of the Dyer: colour from plants and lichens 2nd Edition. New York: Dover Publications, 1993.
13. Chavan, R. B. "Revival of natural dyes--a word of caution to environmentalists." Colourage. April 1995, 42 (4): 27-30.
14. Rosen, Carl J., Peter M. Bierman, and Roger D. Eliason. "Soil Acidification." University of Minnesota Extension Service. Copyright 1998. Dec. 6, 2001. URL: http://www.extension.umn.edu/distribution/horticulture/components/1731-05.html.
15. City of Tucson Environmental Management, Health & Safety in the Arts, URL: http://www.tucsonaz.gov/ets/

Table 1: Common metal mordants and ailments/problems caused by them [11]

Metal	Acute problems	Chronic problems	Toxic concentration
Chromium	GI hemorrhage, hemolysis, acute renal failure (Cr^{6+} ingestion)	Pulmonary fibrosis, lung cancer (inhalation)	No clear reference standard
Copper	Blue vomitus, GI irritation/ hemorrhage, hemolysis	vineyard sprayer's lung (inhaled); Wilson disease (hepatic and basal ganglia degeneration)	Normal excretion: 25 µg/24 h (urine)
Iron	Vomiting, GI hemorrhage, cardiac depression, metabolic acidosis	Hepatic cirrhosis	Nontoxic: < 300 µg/dL Severe: >500 µg/dL

Table 2: Textile mordants and health hazards [15]

Type of Mordant	Other Names	Ingestion hazards	Inhalation hazards	Skin Contact hazards	Other Hazards
Alum	Potassium Aluminum Sulfate, Ammonium Alum, Ammonium Aluminum Sulfate	Slightly toxic to moderately toxic	Slightly toxic	Slightly toxic	May cause irritation and allergies
Copper Sulfate	Blue Vitriol	Highly toxic; causes vomiting, irritation	Moderately toxic	Slightly toxic	May cause skin allergies, irritating to skin, eyes, nose, throat
Cream of Tartar	Potassium Acid Tartrate	Moderately toxic	Slightly toxic	Slightly toxic	Mildly irritating; fatalities have occurred from ingestion of large amounts
Ferrous Sulfate	Copperas	Moderately toxic	Slightly toxic	Slightly toxic	Soluble iron salts are slightly irritating to skin, eyes, nose, throat; can cause poisoning
Oxalic Acid		Highly toxic; severe corrosion	Highly toxic; severe respiratory irritation	Highly toxic; may cause corrosion	May cause shock, collapse, possible convulsions, death
Potassium Dichromate	Potassium bichromate, chrome	Extremely toxic	Extremely toxic	Highly toxic; corrosive	Probable carcinogen; can cause fire in contact w/reducing agents, solvents, organic materials
Stannous Chloride	Tin Chloride	Moderately toxic	Moderately toxic	Slightly toxic	Irritating to eyes, mucous membranes
Tannin	Tannic Acid	Moderately toxic	Slightly toxic	Slightly toxic	Possible carcinogen

Natural dye — an overview

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Abstract

One of the early classes of materials that man found to be useful for protective and other purposes is the fibre class of materials obtained from natural sources. All those fibres used by man from the early days are obtained from vegetables and animal sources. Prominent among them are cotton, flax, ramie, jute etc obtained from forests or by agro efforts and silk, wool and other kinds of animal hairs obtained from insects/animal kingdom. Affairs related to environmental preservation, control of pollution and use of energy efficient materials and processing have renewed interest for use of natural fibres. It is imperative that such natural fibres should be processed following related environmental requirements to have little/no adverse impact on the production ecology, user ecology and disposal ecology. Natural dyes or colourants obtained from renewable resources, such as, plants and animals have been receiving increasing attention in the recent times in view of its environment friendly character. Technologies associated with colouration of natural fibres with natural dyes have yet to pass through stages of refinements and sophistications to suit newer demand and to eliminate or to improve upon some known deficiencies or disadvantages and additionally, to infuse efficiency in processing, enhance durability of processed end use products and also to make them more acceptable, comfortable and attractive.

***Keywords*:** Cotton, Dyes, Mordants, Pigments, Silk.

Introduction

Natural dyes are the dyes and pigments obtained from renewable resources of nature, such as plant and animal, although natural dyes from minerals of the earth are also known [1]. Colouring matter derived from different organs of a plant, such as root, leaf, bark, trunk or fruit are known as vegetable dyes; while the colouring matter obtained from the animal kingdom such as lac, cochineal and kermes are known as animal dyes. Colouring matters obtained from various inorganic metal ores and metal salts are known as mineral dyes [1, 2]. Natural dyes find application chiefly for colouration of food, drugs, cosmetics and textile. Some quantities of dyes are also used for colouration of paper, leather, shoe-polish, candle, wood etc [3].

Use of natural dyes for colouration of textile is practiced since early days [4]. After the synthesis of Mauveine by William Henry Perkin [4] and its subsequent commercialization, the use of natural dyes receded and the position continued to be much the same until in the recent past growing consciousness about environmental preservation and control of pollution and conventional wisdom and belief regarding environment friendliness of natural dyes have renewed interest for use of natural dyes for the colouration of textile [2, 5-7].

The advantages and major attractions of natural dyes are as follows:

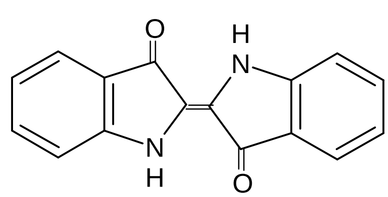
- They are obtained from renewable resources
- They pose no health hazards
- Their extraction involves mild or no chemical reactions
- They pose no disposal problem
- They are harmonized with nature
- They offers soft, soothing and uncommon shades
- Locally available plants and vegetable waste can be used as natural dyes
- Use of natural dye is a labour intensive process; thereby it provides job opportunity for all those engaged in cultivation, extraction and textile application.

However, the inherent drawbacks of the natural dyes and its applications are:

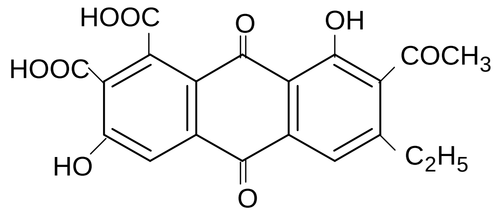
- Ability to dye chiefly natural fibres
- It is difficult to standardize the recipe and methods for the use of natural dyes
- Most of the natural dyes with a few exception require the use of mordant to fix them on to the fibre
- The aqueous extract of natural dyes causes fungi growth if not used within 24 - 48 hours. Preservation of the aqueous extract of natural dye is very essential in order to store the dyestuffs for a longer time without affecting the colour strength.
- Lack of availability of standardized methods and precise technical know-how on extraction and dyeing technique for application of natural dye.
- Application of natural dyes are sometimes expensive and time consuming process
- Reproducibility of shades
- Use of salts of red-listed transition metals such as copper, cobalt and chromium [8,9]

Classification of Natural Dye

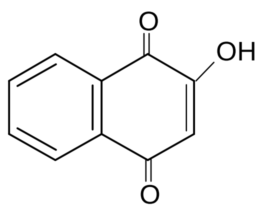
Natural dyes cover a wide range of chemical classes including indigoid, anthraquinone, alpha-naphthoquinone, flavones, flavonols dihydropyrans, anthocyanidins and carotenoids [1, 10]. Some of the typical structures of natural dyes belonging to different chemical classes are given in Fig. 1:



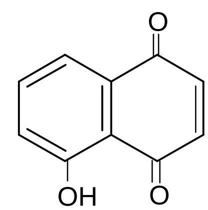
(i) Indigo



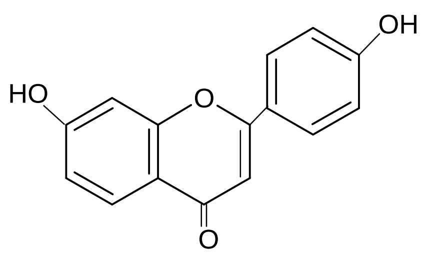
(ii) Laccaic acid (Lac dye)



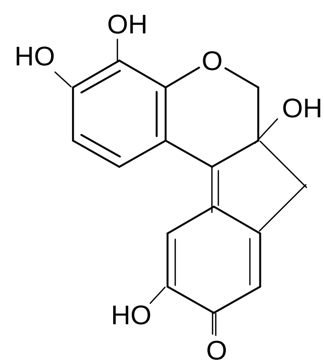
(iii) Lawsone



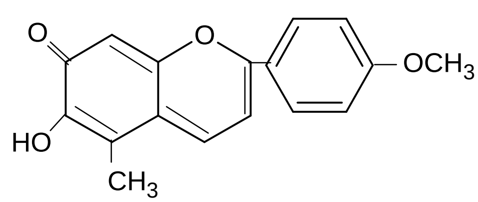
(iii) Juglone



(iv) Sandal wood



(v) Logwood



(vi) Carajurin

Fig.1: Chemical structures of (i) Indigoid, (ii) Anthraquinone, (iii) Alpha- Naphthoquinone, (iv) Flavones, (v) Dihydropyrans and (vi) Anthocyanidins based natural dyes

Natural dyes were initially classified into two groups, such as substantive and adjective dyes [1]. Substantive dyes were those, which appear to have affinity for the substrate and adjective dyes were those, colouration with which could be accomplished only in presence of one or any two from the following: metal salts, tannins or tannic acid and oil. Such compounds that create affinity of natural dye for the fibre are known as mordant. Among the metal and its oxides, potassium dichromate, stannous chloride, stannic chloride, ferrous sulphate, cupric sulphate and alum are commonly used as mordants. Crushed leaves of sumach and powdered myrobolan containing tannin and tannic acid are also employed as mordant. Natural oils containing fatty acids such as, palmitic, stearic, oleic, etc and also sulphonated castor oil are used for the purpose [1].

In the recent past the dyes were classified mostly depending on their application method on different substrates as direct, acid, basic, vat and disperse classes of dyes in a similar manner the synthetic dyes are classified [1,11, 12]. Many natural dyes appear to produce more than one colour in presence of different mordants.

What are Mordants and Mordanting?

The word 'mordant' has been derived from the Latin word 'modere', which means 'to bite' i.e. the compounds which create affinity of natural dye for the fibre are known as mordant. Among the metal and its oxides, potassium dichromate, stannous chloride, stannic chloride, ferrous sulphate, cupric sulphate and alum are commonly used as mordants. Crushed leaves of sumach and powdered myrobolan containing tannin and tannic acid are also employed as mordant. Natural oils containing fatty acids such as, palmitic, stearic, oleic, etc and also sulphonated castor oil, commonly known as T.R.Oil are used for the purpose.

Mordanting is a process of application of aqueous solution of any mordanting agent on the fabric/yarn to improve the affinity of the dye to the fibres, to be used before dyeing (pre-mordanting), during dyeing (simultaneous mordanting) and after dyeing (post-mordanting) as applicable or needed.

Application of Natural Dye (Vegetable origin)

Dye Extraction

Natural dyes are available in the market in crude form, crushed form, water extracted powder form and paste form. Natural dyes in crude form or crushed form can be extracted with water at boil for 45 minutes to 1 hour. Aqueous solution of natural dye is prepared by adding a fixed quantity of vegetable matters (bark, flower, root, trunk, fruit etc.) to a fixed quantity of water. The mixture is stirred, heated and kept at boiling point for 45 minutes, allowed to stand for 15 minutes and finally filtered. This filtrate can be diluted to different extent for producing shades of different depth. The filtrate is then used as natural colourants for dyeing of textile materials. But in case of water extracted powder form and paste form this extraction procedure is not required and one can save the extraction time. In those cases a fixed quantity of dye is dissolved in fixed quantity of water and this aqueous solution can be directly used for the dyeing purpose. This solution can also be diluted to different concentrations for producing different shade depth.

Procedure of Dyeing

Cotton Yarn

Before dyeing, the cotton yarn/fabric should be properly scoured and bleached to remove all the added and natural impurities. Mercerized yarn will produce better effect in respect to colour yield or depth of shade. Bleaching should be done with hydrogen peroxide, hypochlorite beaching is not preferred. After scouring and bleaching the yarn must be properly washed and then taken for dyeing.

Silk Yarn

In case of silk yarn/fabric, it must be properly degummed and bleached (if required) and washed prior to dyeing.

Application in absence of mordant

Dyeing of cotton and silk substrates with aqueous solution of natural colorants is done at a material to liquor ratio of 1:15 to 1:20. Dyeing is carried out at 80-90^{0}C temperature for 20-30 minutes. In case of silk yarn it is better to add acetic acid in the dye bath to maintain the pH at around 5 for achieving better exhaustion. Soaping of the dyed substrates should be done employing 1-2 g/l non-ionic detergent at 50 ^{0}C for 5 – 10 minutes.

Application in presence of mordant

Application of aqueous solution of natural dyes can be selectively done in presence of mordants following a pre- and post- mordanting method.

In case of cotton substrates post-mordanting technique can be followed. In this method the cotton yarn is first dyed with the natural colourants at 80-90^{0}C temperature for 20-30 minutes and dyed yarn (without any further wash) is mordanted in a separate bath at a temperature of 70^{0}C for 15-20 minutes along with a little amount of acetic acid to prevent formation of metallic hydroxide, which may give faulty dyeing. Soaping of the dyed material is done employing 1-2 g/l non-ionic detergent at 50 ^{0}C for 5 – 10 minutes. In case of cotton, primary mordanting with T.R.Oil or harda (myrobolan) can be done before final mordanting with metal salts. But this primary mordanting with harda affects the tone of the final shades.

In case of silk yarn both pre- and post mordanting methods can be adopted. In pre-mordanting method, the silk yarn is first immersed in an aqueous solution of mordant for 15-20 minutes at 70^{0}C. But an important point is that a little amount of acetic acid required to be added in the mordanting bath to prevent formation of metallic hydroxide, which may give faulty dyeing. The mordanted yarn/fabric is then dyed with natural colourants at 80-

90^0C for 20-30 minutes. For both mordanting and dyeing operations the material to liquor ratio is maintained at 1:15 to 1:20. Soaping of the dyed yarn should be done employing 1-2 g/l non-ionic detergent at 50^0C for 5 – 10 minutes.

The following precautions should be taken while using natural dyes for the coloration of textile materials:

- Metal salts should be used in such nearest possible quantity to avoid wastages and to minimize sewage pollution as well as not to exceed the limit of eco-parameters for textiles or not to be included in the list of objectionable heavy metal.
- The final dyed materials should always be washed with non-ionic liquid detergent to remove the surface colours and to improve wet fastness properties. Ordinary soap or detergent available in the markets should not be used as it contains sodium compound, which may cause severe change in tone of the final shade.
- Water used for extraction should be free from metallic impurities and hardness of around 50 ppm is recommended.
- The aqueous extraction with alkali is the most common methods, but these may change the actual tone or hue of the actual colour. So it is always better to extract the dyes with water.

Reference

1. *Natural Dyes and Their Application to Textiles*, Ed. M L Gulrajani and D B Gupta (Indian Institute of Technology, New Delhi), 1992.
2. J D Hill, *Rev Prog Col*, 27 (1997), p19.
3. M L Gulrajani, *Indian J Fibre Text. Res*, 26 (3&4), (2001), p191.
4. E R Trotman, *Dyeing and Chemical Technology of Textile Fibres*, 1st edn, (B I Publications Pvt. Ltd., New Delhi), 1994.
5. B Glover, *Textile Chemist Col*, 27(4), (1995), p17.
6. T Dheeraj, T Priyanka and M Monica, *Colourage*, 50(7), (2003), p35.
7. E M Dedhia, *Colourage*, 45(3), (1998), p45
8. R A Lal, *Colourage*, 42(1), (1995), pp55-56.
9. S R Shukla, *Colourage*, 53(8), (2006), p75.
10. M L Gulrajani, *Colourage*, 46(7), (1999), pp19-28.
11. V K Mishra, *Colourage*, 46(7), (1999), p31.
12. N Sekar, *Colourage*, 46(7), (1999), pp33-34.