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Eco-friendly approaches to rejuvenate the Khadi udyog in Assam

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The handloom workers were the poorest, least respected, socially and economically deprived, living in debts and almost living like an island in the Indian society still in the 21st century. Besides, in large parts of India, handloom weaving lost its fame and prosperity. Basically, handloom weaving is a men's domain but at this juncture, the significant contribution of women workforces cannot be over ruled. In the present study, efforts were made to make khadi fabrics more attractive with innovative designs through printing with colourants extracted from natural resources. In this article, a cost-effective and user-friendly technology for extraction of natural dyes from indigenous natural resources of northeastern part of our country has been developed. Those dye solutions is used for printing of eri silk and cotton fabrics in presence of various eco-friendly mordants in order to develop innovative designs for the markets with good colourfastness properties.

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Indian handloom industry is a part of country's culture and one of the oldest cottage industries diffused widely throughout the country. It contributes nearby 15% of the total cloth production and 95% of the world's hand-woven fabric comes from India. This sector has been sustained by transferring skills from one generation to another and the strength of this sector lies in its uniqueness, flexibility of production, openness to innovations, adaptability to the supplier's requirement, etc. In spite of that, the handloom workers are the poorest and least socially respected and also economically deprived[1]. This heritage industry plays a very imperative role in the India's economy and has the potential to create ample opportunities of employment generation amongst the rural people[2]. On the other hand, the term 'Khadi' entered in nationalist vocabulary in the early 20th century and the cloth became a key visual symbol of India's struggle from colonial rule[3]. It was a practical attempt to relieve the poverty and uplift the standards of Indian village people and thus Khadi was a vital part of non-cooperation movement. Gandhi ji believed that the revival of hand-spinning and hand weaving will make the largest contribution to the economic and the moral regeneration of India.

In the modern era of eco-friendly textiles, it is very imperative to use the eco-friendly dyes and chemicals in the wet processing operation. This research deals with the extraction of natural dyes from locally available sources and applies those dyes on khadi fabric through block printing methods in order to achieve variety of shades with soothing colour with attractive design and good colour fastness properties. This research will certainly help handloom weavers and dyers to develop new colours apart from what they are doing usually. These eco-friendly dyed and printed products will motivate the people in handloom sector to use the dye yielding plants[4-7]. Importance of natural dyes is more significant worldwide in the context of increasing environmental awareness[8-13]

North East Region (NER) of India is full of biodiversity and most of the dye-yielding plants are abundantly available in the forests and other wastelands. Traditional knowledge of dyeing and printing is mostly confined among few surviving villagers and tribal dyers in the states. The major information gaps found in natural dye production to consumption value chain are mainly the lack of commercial availability of natural dyes, lack of

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adaption of proper technology, inadequate attentiveness amongst different end-user sectors, deficient in quality standards for naturally dyed products.

Parkia speciosa, also known as stink bean is very popular in northeastern part of our country and it bears long and flat beans pod with green seeds. These plant materials have wide range of application in the field of food and pharmaceutical industry. These pods are regarded as waste materials during the processing in the food industry and thus have the potential to be used as colourants for textile substrates. These bean pods contain abundant phenolic, gallic acid, flavonoids and antioxidative substances[14].

Punica granatum is cultivated in tropical and subtropical parts and is appreciated for its cool refreshing juice with sweet acidic taste and also for its medicinal properties. The skin of such fruit is red to brown in colour and colouration of textile can be done using such colour of the skin, when extracted with water. Fruit rind contains nearly 25% of an ellagi-tannin-flavogallol[15].

Caesalpinia sappan, commonly known as sappan wood, is cultivated in the gardens for its large, ornamental panicles of yellow flowers. The wood is orange-red in colour, hard, very heavy, and straight grained with a fine and even texture. The heartwood of the plant is widely used in traditional medicines. Due to its vast and proven medicinal properties and use as dyeing agents, the wood has received both domestic and international markets[16]. The Colouring matter inside Sappan wood is Brazil in which gives red or purple shades [17].

The Indian madder (*Rubia cordifolia*) is an anthraquinonoid based red dyes and the main colouring matter present in the roots of *Rubia cordifolia* is a mixture of purpurin. *Rubia cordifolia* is one of the well-known drugs being used since ancient time and it has wide range of pharmacological properties. It is also one of the highly reputed drugs used in the indigenous system of medicine as an antiflammatory, to treat urinary disorder, tuberculosis and intestinal ulcer[18].

Myrobolans, locally known as harda, (*Terminalia chebula*) is popularly referred to, is the source of one of the most important vegetable tanning materials and has been used in India for a long time as a tanning, mordanting and dyeing material. It is also of great importance in Ayurvedic medicine and is one of the three key ingredients in triphala, a natural compound that provides overall support for digestive function. It can also be used to treat gastrointestinal and respiratory disorders. The tannin of myrobolan is elagitannic acid [18].

The genus *Clerodendrum* (*L)*, locally known as 'kuthap' belongs to Lamiaceae family. It is widely distributed in tropical and subtropical regions of the world and is comprised of small trees, shrubs and herbs [19]. The leaf of this dye yielding plant produce green colour due to the presence of both chlorophyll a and chlorophyll b in the range of 7.43 mg g-L and 2.87 mg g-L respectively[20]. This tree has some medicinal properties and flavonoids present in *Clerodendrum* also responsible for few biological activities.

In the above context, the present research work is carried out at Indian Institute of Handloom Technology, Guwahati and department of Silpa-Sadana under Visva-Bharati (A Central University) with the following objectives:

- To develop standard shade on eri and cotton khadi fabric with natural dyes
- To dye and print eri and cotton khadi fabrics with indigenous natural sources.
- To train the tribal groups of north eastern region on the shade development and dyeing/printing process.
- To measure various quality parameters in terms of fastness properties.

Materials

Eri silk

2/140 Nm hand spun Eri silk yarn purchased from the local market of Guwahati, Assam was used in the present study.

Cotton

30^s Ne hand spun cotton yarn purchased from the local market of Guwahati, Assam was also used in the present study.

Khadi fabric

Those hand spun yarns were then used for producing Khadi fabrics in handlooms after following the standard preparatory processes before weaving at Indian Institute of Handloom Technology, Guwahati.

Chemicals

Laboratory reagent (LR) grade aluminum sulphate, ferrous sulphate procured from M/s Beekay Scientific

Corporation Ltd., Guwahati was used in the present work. All other chemicals used were of commercial grade.

Natural Dyes

Parkia speciosa (Bitter bean), *Punica granatum* (Pomegranate), *Rubia cordifolia* (Indian Madder), *Caesalpinia sappan* (Sappan wood), *Terminalia chebula* (Harda) and *Clerodendrum indicum* (Kuthap) collected from local areas and were used as natural dyes for dyeing/printing purpose. Table 1 shows details of plant used for the present work in terms of common name, botanical name, parts of the plant and colour produced.

Methodology

Extraction of natural dyes

Aqueous solution of all the natural dyes was prepared as per the standard process[13]. All the bio resources were dried in absence of direct sunlight followed by crushing in a pulverizer. In the present study 100 g of each natural source was added to 1 L of water separately. The mixture was stirred, heated and kept at boiling point for 60 min in a thermostat-controlled beaker dyeing machine, allowed to stand for 15 min and finally filtered. Such filtrate was used for dyeing purpose after diluting it to the specified level, if required.

Dyeing of eri and cotton fabric

Eri and cotton fabrics were dyed with the vegetable colourants as mentioned earlier in presence and/or absence of different mordants by following pre-mordanting method. Aluminium sulphate, ferrous sulphate and Myrobolan (*Terminalia chebula* Retz) was used as mordanting agents. In pre-mordanting method, eri and cotton fabrics were treated with aluminium sulphate and ferrous sulphate (10 g/L) separately followed by dyeing with the aqueous extracts of vegetable resources. In case of Myrobolan 10% (o.w.f) was used as mordants. Mordanting process was performed at 70°C for 20 min keeping a fabric to liquor ratio of 1:30. Dyeing of mordanted fabrics was carried out at 90°C for cotton and 80°C for eri for 45 min at fabric to liquor ratio of 1:30. In case of eri, dye bath pH was maintained at 5 with the help of acetic acid. After dyeing all the fabrics were washed with 2 g/L non-ionic detergent at a temperature of 50°C for 10 min, followed by cold washed and finally dried in air.

Printing with natural colour

In the traditional process of printing the fabric was not actually printed with natural dyes as in the case of synthetic dyes. In this case, the fabric was first treated with Myrobolan followed by printing with metallic salt as a mordant. These printed fabrics were then dyed with the specified natural dyes as mentioned earlier for achieving various shades.

For achieving printing on white ground, inorganic salts of specified dose level were mixed with the aqueous solution of natural colourants and kept for 15 min in order to form lake or complex. Appropriate amount of gum indulka was then added with the help of high speed stirrer to prepare the print paste. Printing on bleached fabric was performed with the help of blocks/screen and after printing fabrics were dried, followed by steaming at 102^0C for 30 min and washed thoroughly with 2 g/L non-ionic detergent, followed by cold wash and finally dried in air.

Evaluation of surface colour strength of dyed fabrics

Dye receptivity of eri and cotton fabrics dyed with natural colourants was estimated in terms of K/S (Kubelka Munk-function) values using Spectra Scan 5100+ computer colour matching system[21].

$$\frac{K}{S} = \frac{(1 - R)^2}{2R}$$

where 'K' is the absorption coefficient and 'S' is the scattering coefficient and 'R' is the reflectance of the dyed fabric at the wavelength of maximum absorption.

Table 1 — Details of the plant used for the experiment

Common name	Botanical Name	Colour produced	Parts used
Bitter bean	*Parkia speciosa*	Reddish to Brownish	Peels of bean
Pomegranate	*Punica granatum*	Red to Slight Yellow	Fruit rind
Indian madder	*Rubia cordifolia*	Pink, Red, Orange, Browns.	Root, stems
Sappan wood	*Caesalpinia sappan*	Red/ Purple	Inner Part
Kuthap	*Clerodendrum indicum*	Pale Green	Leaves
Harda	*Terminalia chebula*	Yellow	Fruit

Table 2 — Different property profiles of dyed fabrics

Fabric	Natural dye used	K/S value	Colourfastness to rubbing		Colourfastness to washing	
			Dry	Wet	Change in colour	Staining on adjacent fabric
Cotton	*Parkia speciosa*	3.7	4	3-4	3-4	4
Eri		4.5	4-5	4	4	4
Cotton	*Punica granatum*	3.4	4	3-4	3-4	4
Eri		4.9	4-5	4	3-4	4
Cotton	*Rubia cordifolia*	3.1	4	4	4	4
Eri		4.6	4	4	4	4-5
Cotton	*Caesalpinia sappan*	4.2	4	4	4	4
Eri		5.7	4	4	4	4-5
Cotton	*Clerodendrum indicum*	3.7	4-5	4	3-4	4
Eri		5.8	4-5	4	3-4	4

Assessment of colourfastness to washing

Colourfastness to wash of dyed cotton yarn was assessed in a launder-o-meter in accordance with a method prescribed in IS 105-C10 (2006) [superseding IS: 3361-1984 (ISO-II)] [22].

Assessment of colourfastness to rubbing

This was determined employing a Crockmeter following the method as prescribed in IS: 766-1988 [23].

Results and Discussion

Dyeing of eri and cotton fabric was carried out with *Parkia speciosa*, *Punica granatum*, *Rubia cordifolia*, *Caesalpinia sappan* and *Clerodendrum indicum* in presence of different mordants at a temperature of 80°C and 90°C respectively. Dye bath pH was kept acidic in case of eri due to alkali sensitivity of protein fibre. During printing all the fabrics was treated with Myrobolan followed by printing with metallic salts as a mordant. After printing, the fabrics were dyed with natural dyes as specified. The K/S values, colour fastness to washing and rubbing of dyed eri and cotton fabrics are enlisted in table 2.

From the table it is observed that both eri and cotton dyed with natural colourants as specified commonly exhibit good wash and rubbing fastness properties. The K/S values obtained for eri fabric is more than that of cotton. It may be due to the better affinity of those colourants on protein fibres as compared to cellulosic counterpart. Fig. 1 shows hand woven eri and cotton fabric dyed and printed with natural dyes.

Fig. 1 — Dyed and printed eri and cotton khadi fabric

Conclusions

Eri and cotton fabric dyed and printed with natural dyes as specified exhibit good colourfastness to washing and rubbing properties. The surface colour strength measured in terms of K/S is higher in case of eri than that of cotton. This eco-friendly method of dyeing and printing will create a new opportunity for the people engaged in the process of manufacturing khadi fabric. The surface ornamentation through block print and dyeing will make them self-sustainable for the rejuvenation of Khadi Udyog in Assam.

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