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Extraction of Dyes from *Petrocarpus santalinus* and Dyeing of Natural Fibres Using Different Mordants

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Abstract
Aqueous extraction of natural dyes from Petrocarpus santalinus tree wood and dyeing of the following natural fibres: banana fibre, screw fine fibre, pineapple fibre, sisal fibre, korai and palm leaf using various mordants to fix the colour in the fibre materials were performed. Salt, sodium bicarbonate, oxalic acid, tannic acid, ferrous ammonium sulphate, stannous chloride (tin metal powder), alum and tamarind (Tamarindus indica) were used as a mordant for the dying of the natural fibres. Petrocarpus santalinus dye was effectively dyed on natural fibres using different mordants, producing different colours like tomato, maroon, orange red, chocolate, brown, quarry red, black, brick red, tile red, terra colla, sunbaked clay, gray, brick red, victorian red, firebrick, brown, crimson and orange, using these mordants.

Key words: *Petrocarpus santalinus, natural fibres, mordant, plant dyes.*

Introduction

Natural dyes and natural fibre products receive much attention these days, as they play a major role in traditional dyeing industries, where natural dyes are extracted from various plant parts, animals, minerals and other natural substances. The usage of natural dyes and natural fibres increases day by day because they are eco-friendly i.e. they do not cause any ill-effects to the environment, being easily degradable, less toxic and allergenic, compared to synthetic dye [1-3]. Natural dyes are used in a variety of ways, for example, in the dyeing of hair, food preservatives, for the antimicrobial (antibacterial, antifungal) efficacy of traditional products, in the textile industry, and as coloring agents in food and lathers etc. [4-12].

The identification and usage of synthetic dyes entered into the textile industry from the nineteenth century [13]. High colour value and cost effective synthetic dye caused a rapid decline in the use of natural dyes. Synthetic dyes are highly toxic, hazardous to the environment and the human body, causing human skin and lung problems. While natural dyes are low toxic, less polluting, less health hazardous, non- carcinogenic and non-poisoning. Natural dyes have several advantages, but with some limitations, one of which is fastness [14].

The dye coated fabric/yarn and fibre products fade with exposure to light or during washing out. Mordants are a substance to fix the colour in fabric and fibres for a long time. Interest in using natural fibres such as different plant fibre and wood fibres as reinforcement in plastics has increased dramatically during the last few years, for example, flax, hemp, jute, sisal and banana [15]. In this study, we investigated dye extracted from the plant *Petrocarpus santalinus* for the dyeing of natural fibres using different mordants, as well as their dye absorption (spectral).

Materials and methods

Dried *Petrocarpus santalinus* wood was purchased from the Ayurveda shop, Kanyakumari (Dist), Tamilnadu, India. The intact materials were powdered and stored at room temperature without moisture content. Salt, sodium bicarbonate, oxalic acid, tannic acid, ferrous ammonium sulphate, stannous chloride (tin metal powder), alum and tamarind, which were all the chemicals used in this study, were of lab reagent grade. Banana fibre, screw fine fibre, pineapple fibre, sisal fibre, korai and palm leaf fibres were collected from local NGO's and craft workers.

Five grams of powdered *Petrocarpus santalinus* wood was soaked in water (100 ml) for 10 min and heated at 80 °C for an hour. During this time, the colorant was extracted and filtered using Whatmann No. 1 filter paper [16]. The dye solution extracted was subsequently used for dyeing, and for finishing of the fibre different mordants viz., salt, sodium bicarbonate, oxalic acid, tannic acid, ferrous ammonium sulphate, stannous chloride (tin metal powder), alum and tamarind were used to fix the dye

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Table 1. *Light fastness analysis of natural dye coated fibre materials. 1 – poor, 2 – slight 3 – moderate 4 – fair, 5 – good , 6 – very good, 7 – excellent and 8 – maximum.*

Fibre	Dye without mordant	Dye with							
		Salt	Sodium bicarbonate	Oxalic acid	Tannic acid	Ferrous (FAS)	Tin	Alum	Tamarind
Palm leaf	3	4	4	4	4	5	4	4	4
Korai	2	3	2	4	3	4	3	3	3
Banana	3	3	3	4	4	5	5	5	4
Screwpine	3	2	4	3	3	4	3	4	4
Sisal	3	3	3	4	4	4	4	4	4
Pineapple	4	3	3	4	3	4	5	4	4

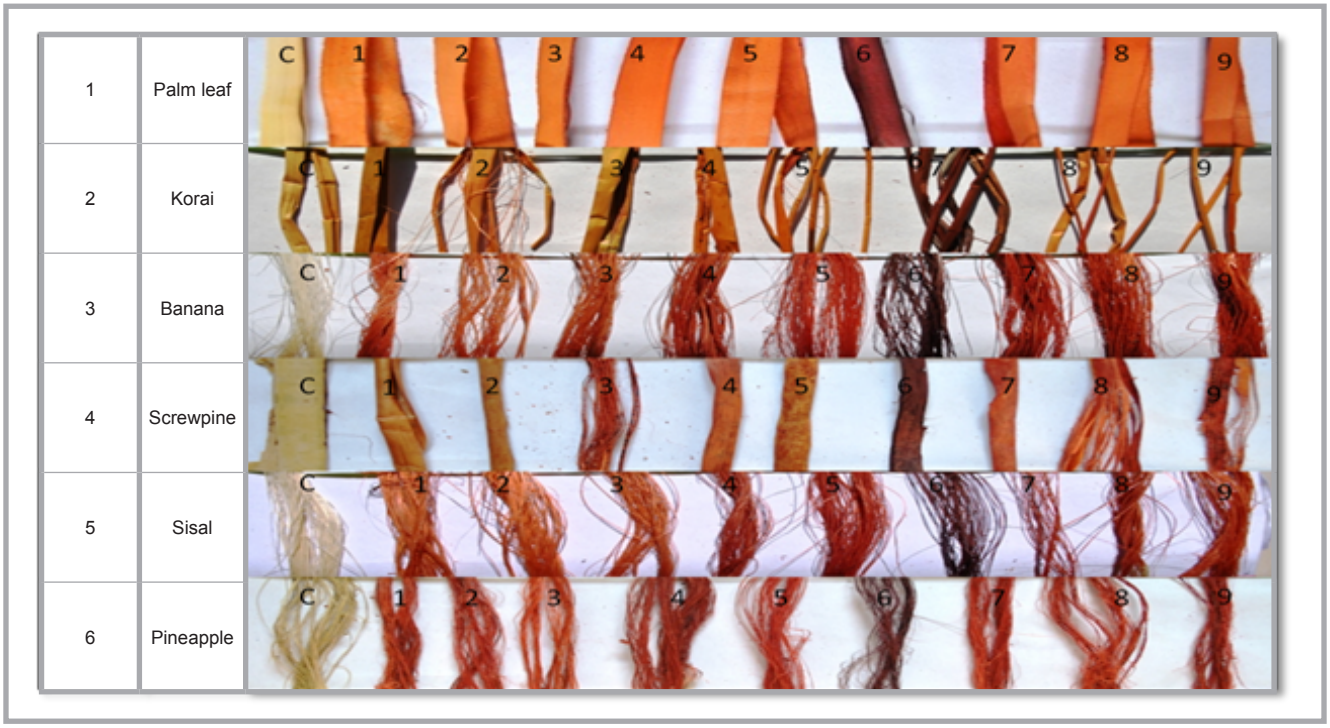

Figure 1. *Petrocarpus santalinus dye coated natural fibre materials (before washing). C-Control, 1 – without mordents, 2 – salt, 3 – sodium bicarbonate, 4 – oxalic acid, 5 – tannic acid, 6 – ferrous ammonium sulphate, 7 – stannous chloride (tin metal powder), 8 – alum and 9 – tamarind.*

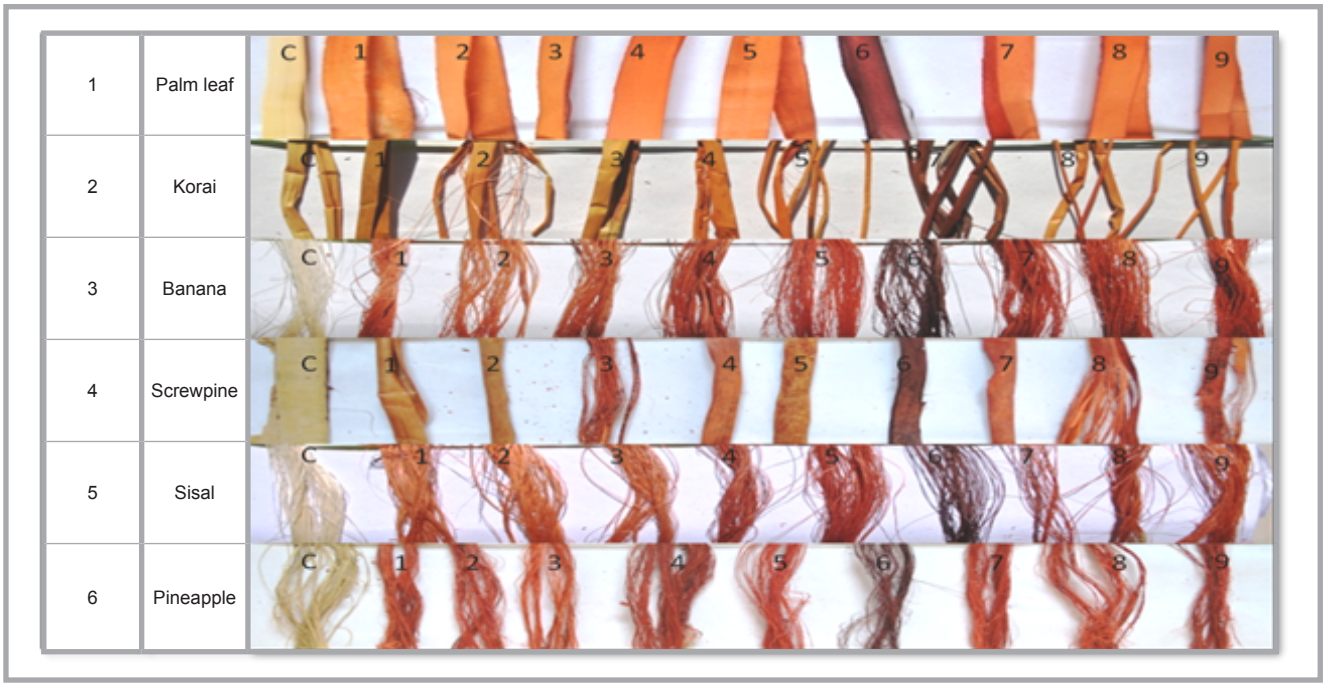

Figure 2. *Petrocarpus santalinus dye coated natural fibre materials – after washing.*

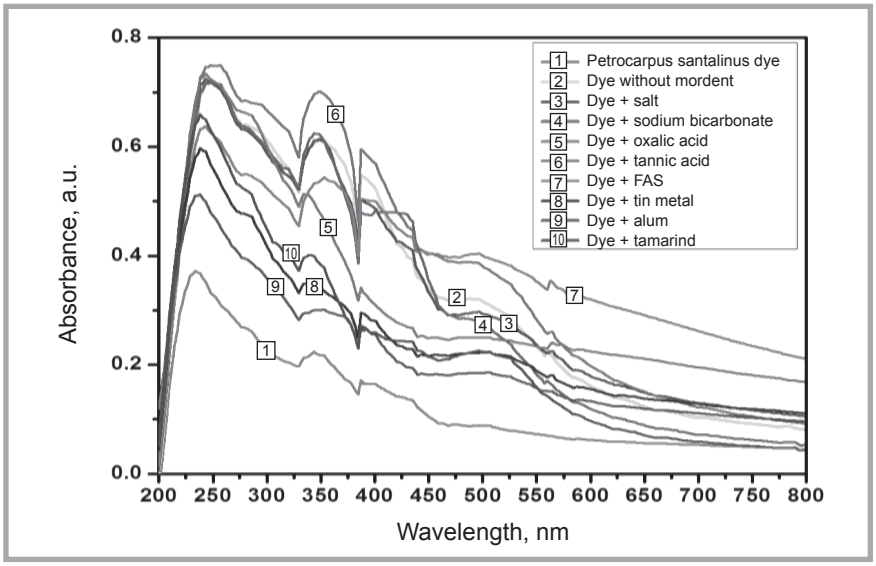

Figure 3. *UV/Visible spectral data of natural dyes.*

on the various natural fibres, i.e. banana fibre, screw fine fibre, pineapple fibre, sisal fibre, korai and palm leaf fibres. All the experiments were carried out in a mud pot (vessel).

The washing procedure for the dyed materials was as follows: the natural dye coated fibres were washed with 10 ml of tap water, to which 0.1 gm of commercially available detergent (Rin®) was added. This setup was kept under normal room conditions and stirred for 15 minutes using a magnetic stirrer [17, 18].

The light fastness test were performed on the dyed samples exposed to sunlight for 24 h at standard test conditions for evaluation of their light fastness using the gray scale. The rating scale of light fastness was 1 – poor, 2 – slight, 3 – moderate, 4 – fair, 5 – good, 6 – very good, 7 – excellent and 8 – maximum [19, 20].

UV/Vis spectra of extracted natural dye and dye with different mordants were analysed using UV/Visible spectroscopy 2203. The absorption wavelength range observed was from 200 to 800 nm [21].

Result and discussion

The colour values in ***Table 1*** are for natural fibres dyed using *Petrocarpus santalinus* using different mordants. It shows that those moderated with natural mordants like salt, sodium bicarbonate, oxalic acid, tannic acid, ferrous ammonium sulphate, stannous chloride (tin metal powder), alum and tamarind produced a variety of red colours (see ***Table 1***). It also presents the OD value of λmax in 400 nm of natural dye containing different mordants. Dyeing the natural fibres with *Petrocarpus santalinus* dye fibre with different mordants produced different colours like tomato, maroon and orange. For example, red dye on the palm leaf was followed by adding sodium bicarbonate, ferrous ammonium sulphate and tamarind as a mordant. Korai can be effectively dyed in chocolate and brown colour using oxalic acid and ferrous ammonium sulphate. Banana fibre materials are effectively dyed quarry red, black, brick red and tile red colors using sodium bicarbonate, oxalic acid, tannic acid, ferrous ammonium sulphate and tamarind as mordants. Terra colla, sunbaked clay, gray and brick red colours can be dyed on screw fine fibres using sodium bicarbonate, tannic acid, ferrous ammonium sulphate and alum as mordants. Sisal fibres can be effectively dyed in chocolate, tile red, Victorian red, firebrick and brown colors using salt, tannic acid, ferrous ammonium sulphate, alum and tamarind as mordants. Pineapple fibres are effectively dyed crimson, firebrick, orange, gray and brown colors using salt, oxalic acid, ferrous ammonium sulphate, alum and tamarind as mordants (***Figure 1***).

After washing, the dye coated natural fibres underwent no changes (***Figure 2***); however, without mordanting, some alterations were observed fibre.

The dyed samples were exposed to sunlight for 24 h for evaluation of their light fastness using the gray scale (***Table 1***). Among the different mordants used to dye the natural fibres ferrous ammonium sulphate, tin metal and alum had better fastness properties than other mordants (***Table 1***).

UV spectra of the *Petrocarpus santalinus* dye with and without mordants were recorded (***Figure 3***). The UV spectrum of *Petrocarpus santalinus* dye was characterised by a single major absorbance at 233.2 nm. After dyeing of the natural fibres without a mordant, *Petrocarpus santalinus* dye was characterised by the presence of three major absorbances located at 243.2, 348.8 and 387.2 nm. With salt (mordant) it was characterised by the presence of three major absorbances located at 243.2, 348.8 and 387.2 nm. With sodium bicarbonate it (mordant) was characterised the presence of three major absorbances located at 243.2, 344.0 and 387.2 nm. With oxalic acid (mordant) it was characterised by the presence of a single major absorbance at 243.2 nm. With tannic acid (mordant) it was characterised by the presence of three major absorbances located at 248, 344 and 387.2 nm. With ferrous ammonium sulphate (mordant) it was characterised by the presence of three major absorbances located at 243.2, 353.6 and 387.2 nm. With tin metal powder (mordant) it was characterised by the presence of a single major absorbance at 238.4 nm. With alum (mordant) it was characterised by the presence of a single major absorbance at 233.6 nm. With tamarind (mordant) it was characterised by the presence of a single major absorbance at 238.4 nm.

Conclusion

In the international market, handicraft products (***Figure 4*** see page 23), especially made of natural fibres (banana fibre, screw fine fibre, pineapple fibre, sisal fibre, korai grass and palm leaf fibres etc.) face many problems. Synthetic dyes that are polluting agents and have carcinogenic properties and toxicity are used to colour natural fibres. Thus these fibre products are not sustainable on the market. However, there are millions of artisans that depending on crafts directly and indirectly, for whom natural dyes are an alternative to synthetic dyes as the former are eco-friendly, nontoxic, and do not have any carcinogenic properties.

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Figure 4. *Handicraft products made of Petrocarpus santalinus dye coated natural fibre materials.*

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