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Extraction and application of natural dye preparations from the floral parts of *Woodfordia fruticosa* (Linn.) Kurz

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India has a rich biodiversity and harbours a wealth of useful germplasm resources and there is no doubt that the plant kingdom is a treasure-house of diverse natural products. One such product from nature is the dye. Dyes are one of the most important uses of the plants. Recently, interest in the use of natural dyes has been growing rapidly due to the result of stringent environmental standards imposed by many countries in response to toxic and allergic reactions associated with synthetic dyes. Nature has gifted us more than 500 dye-yielding plant species. One such medicinally much used dye-yielding plant species, *Woodfordia fruticosa* (Linn.) Kurz is exploited particularly, in perfume, leather and textile industry and believed to be superior for woolen and silk fabrics. The present study deals with the extraction of natural dye from this species, commonly known as Fire-Flame Bush, and their application on textiles. Three different techniques/methods for extraction of dye from the collected flowers were evaluated to determine the best extraction method. Three different types of fabrics and three different types of yarns were used in the experiment to observe the strength of dye. Cotton Jute mix sample showed dark yellowish brown colour with Myrobalan, dark blackish brown colour with Ferrous Sulphate, Camel colour with Stannous Chloride and Yellowish brown with Potassium dichromate.

Keywords: Natural dyes, Dye-yielding plant, *Woodfordia fruticosa*, Fire-Flame Bush, Cotton, Jute.

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Introduction

India has a rich biodiversity and it is not only one of the world's twelve megadiversity countries, but also one of the eight major centers of origin and diversification of domesticated taxa. It has approximately 4, 90,000 plant species of which about 17, 500 are Angiosperms; more than 400 are domesticated crop species and almost an equal number their wild relatives[1,2]. Thus, India harbours a wealth of useful germplasm resources and there is no doubt that the plant kingdom is a treasure-house of diverse natural products. One such product from nature is the dye[3]. Dyes are one of the most important uses of the plants, as they are related with cultural practices, rituals, arts and crafts, fabrics and to satisfy personal embodiment, however, dye yielding plants have not received significant attention. A few publications on the vegetable dyes from India and some state specific reports from West Bengal, Manipur, Arunachal Pradesh, Uttarakhand and others have generated a fresh interest on this aspect[4-9].

Recently, interest in the use of natural dyes has been growing rapidly due to the result of stringent environmental standards imposed by many countries in response to toxic and allergic reactions associated with synthetic dyes[10]. Research has shown that synthetic dyes are suspected to release harmful chemicals that are allergic, carcinogenic and detrimental to human health. On the other hand, 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. Though, dyes have been discovered accidentally, their use has become so much a part of man's customs that it is difficult to imagine a modern world without dyes. The art of dyeing spread widely as civilization advanced[11].

Nature has gifted us more than 500 dye-yielding plant species[8]. One such medicinally much used dye-yielding plant species is *Woodfordia fruticosa* (Linn.)Kurz (Family Lythraceae), commonly called as Fire-Flame Bush, Dhavari and Dhatki. It is a rare,

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much branched, beautiful shrub with fluted stems and long spreading branches; widely cultivated as an ornamental shrub in gardens for its flowers which are borne during the summer season (Plate 1). The plant possesses many medicinal properties. Flowers are the most effective fermentation agent, used in Ayurvedic medicines[12]. The dried flowers are reported to be used for the treatment of haemorrhoids, dysentery, diarrhoea, liver diseases, piles, disorders of mucous membranes, leucorrhoea, menorrhagia, ulcers, wounds, burning sensations, skin diseases, fever, headache, herpes, etc[13].

Materials and Methods

The dye was extracted from the fresh floral parts of *W. fruticosa*, collected from Rajaji National Park, Haridwar and Shivananda Ashram Campus Area, Rishikesh, Uttarakhand in March, 2010 and voucher specimens are deposited in the Rajasthan University's Herbarium (RUBL20635).

Dye extraction

The collected flowers were divided in three parts and extracted separately one after the other, in three different manners and the results were compared to conclude the best extraction method:

1) The first method used for extraction was the aqueous extract from fresh flowers. In this method, dye from flowers were extracted by preparing an aqueous solution of flowers (10 g in 100 mL distilled water) and the extraction process was carried out at a temperature range of 80-85°C for 1h. Colouring materials from the flowers were extracted for dying of the fabric. After the extraction procedure is complete, the flowers were taken out from the liquor and they were taken for extraction of dye for the second time.
2) In the second method of dye extraction, the flowers (uncrushed) (10 g) were placed in 100 mL distilled water as a solvent for extraction. This pasty mass was kept for 10-15 days to get colour of dye. This extract was then filtered and used for dyeing.
3) In the third method of dye extraction, the flowers (10 g) were crushed and put in an earthen pot to which 100 mL water was added. The pot was kept undisturbed for 20-25 days and extract was then filtered through a piece of cloth to yield the natural dye.

Dyeing procedure

The extracts obtained through above mentioned methods were filtered and used for dyeing. Cloth used for dyeing was boiled in NaOH solution (10%) for 15 minutes to remove starch from the cloth, then washed with cold distilled water. This cloth was then transferred in mordant (Myrobalan) for 30 minutes followed by treatment in the dye bath for one hour. Effect of dye without mordanting the fabric was also studied. Then the cloth was treated with tepol (colour fixative) and dried in sunlight (Flow chart 1).

Plate 1—a. *Woodfordia fruticosa* flowering twig; b. Close up view of the spike with flowers

Different types of cotton cloth (10 × 10 cm) and yarns were experimented for dyeing. Three different types of cloth and three different types of yarns were used in the experiment to observe the strength of dye. Cotton–synthetic mix (C1), Cotton pure (C2) and Cotton –Jute mix (C3) were taken. Yarns of silk (Y1), cotton (Y2) and wool (Y2) were taken into account.

Similarly effect of various mordants on colour of dye extracted from the flowers were also studied on the cloth found best in the above experiment. This was achieved by incorporating different mordants like, Stannous Chloride, Ferrous Sulphate and Potassium Dichromate separately, each at a concentration of 3% of the dye extract (5 mL). Cloth pieces were individually soaked with the mixture of extract-mordant solution. After 30 minutes of soaking the cloth was dried in sunlight for 2 hours. The sun dried cloth was further evaluated for its colour, lightness and wash fastness. Wash fastness was tested by washing with soap water (10% w/v) and heat resistance was tested by keeping the cloth at various temperatures, viz. 50, 60, 70°C for 30 minutes in the oven without water.

Cotton/cotton synthetic mix/jute cloth (10 × 10 cm)
↓
Cloth boiled in NaOH solution (10 %) for 15 minutes
↓
Washed with cold distilled water
↓
Transferred in mordant (Myrobalan) for 30 minutes
↓
Treatment in the dye bath (prepared according to the methods explained in dye extraction) for one hour
↓
Treated with tepol (colour fixative) and dried in sunlight
↓
Cloth with best result treated with different mordants like, Stannous Chloride, Ferrous Sulphate and Potassium Dichromate, incorporated separately, each at a concentration of 3% of the dye extract (5 ml).
↓
Cloth pieces individually soaked with the mixture of extract - mordant solution for 30 minutes
↓
Dried in sunlight for 2 hours
↓
Evaluated for colour, lightness and wash fastness

Flow chart showing dyeing procedure

Results and Discussion

A dark yellowish-brown dye was obtained from the flowers of *W. fruticosa* with the second method of extraction. Effects of Myrobalan and dye colour and effect of dye without mordant are presented in Plates 2, 3 and 4 and Tables 1 and 2. The second method of dye extraction, with paste of uncrushed flower was kept for 10-15 days to get colour of dye, gave best colouration and was found to be the best extraction method. Cotton-synthetic mix (C1) showed slight light brown colouration, while Cotton-Jute mix (C3) and pure cotton (C2) cloth samples showed best colouration (dark yellowish-brown and brown) (Plate 2). The intensity of colour produced on cloth and yarns by dyeing without mordanting (myrobalan) was found slightly less than that obtained for myrobalan and dye used successively.

Silk yarn developed an attractive shiny golden brown colour whereas cotton and wool yarn dyed to - brown and dark brown colour, respectively (Plate 3) with the treatment of myrobalan and then dye extracted.

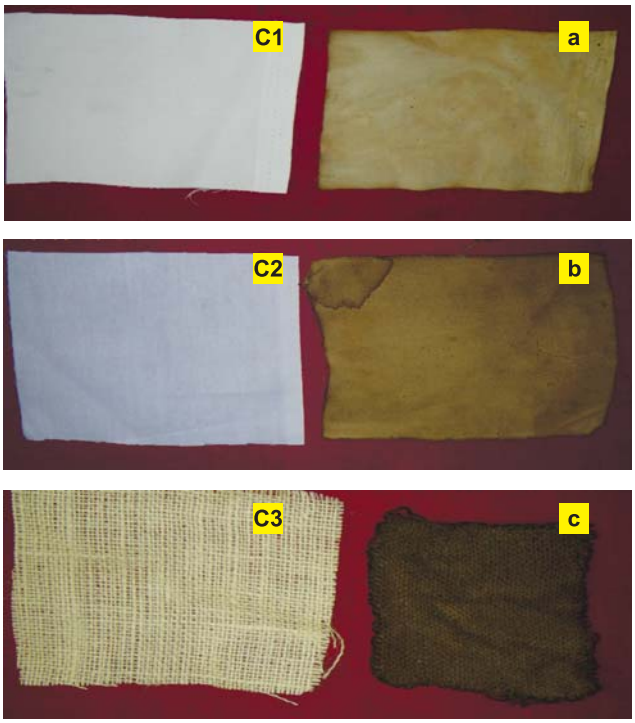

Plate 2—Application of dye extracted from flowers of *Woodfordia fruticosa* + myrobalan on different types of cloth types. A. Untreated white cotton-synthetic mix (C1) cloth and dyed slightly light brown coloured cloth ; B. Untreated white cotton pure (C2) cloth and dyed brown coloured cloth; C. Untreated white cotton-jute mix (C3) cloth and dyed dark yellowish brown coloured cloth.

Plate 3—Application of dye extracted from flowers of *Woodfordia fruticosa* + Myrobalan on different types of yarns-A. Untreated white silk yarn (Y1) and dyed shiny golden brown coloured yarn; B. Untreated white cotton yarn (Y2) and dyed brown coloured yarn; C. Untreated white wool yarn (Y3) and dyed dark brown coloured yarn.

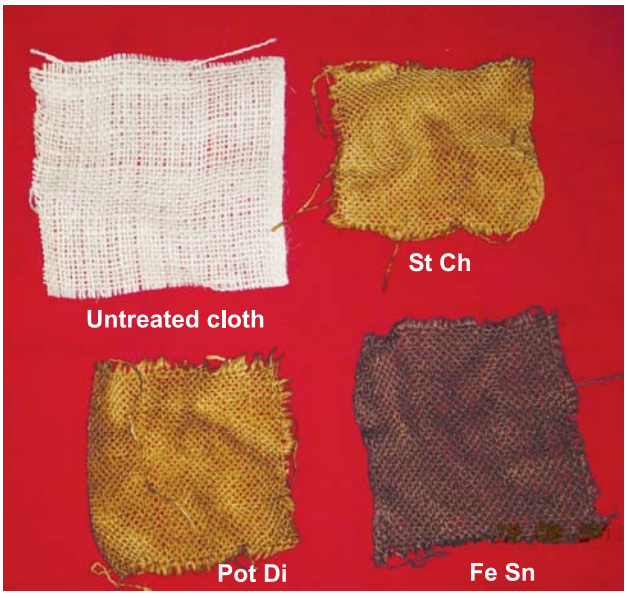

Plate 4—Effect of different mordants on the cotton–jute cloth (C3) with dye obtained. Camel colour with Stannous Chloride, Yellowish brown colour with Potassium Dichromate, Dark blackish brown colour with Ferrous Sulphate.

Table 1—Effect of myrobalan and dye extracted from flowers of *Woodfordia fruticosa* on different types of cloth and yarns

S. No.	Sample	Color obtained with the treatment of dye extract without using myrobalan (mordant)	Color obtained with the treatment of myrobalan+dye extract
1.	Cotton-synthetic mix (C1)	Slight Light Brown	Light brown
2.	Cotton pure (C2)	Light brown	Brown
3.	Cotton- Jute mix (C3)	Brown	Dark Yellowish brown
4.	Silk yarn (Y1)	Yellowish brown	Shiny Golden brown
5.	Cotton yarn (Y2)	Light Brown	Brown
6.	Wool yarn (Y3)	Brown	Dark Brown

Table 2—Effect of different mordants with dye extracted from flowers of *Woodfordia fruticosa* on the cotton-jute cloth

S.No.	Mordants	Color obtained	Color fastness
1.	Myrobalan	Dark Yellowish brown	Slight
2.	Stannous chloride	Camel Colour	Slight
3.	Ferrous sulphate	Dark Blackish brown	Slight
4.	Potassium dichromate	Yellowish brown	Slight

Cotton-jute cloth showed best colouration (Plate 2) after treating with dye, hence it was further selected for dyeing with mixture of different mordant and extracted dye. When cotton-jute mix cloth (C3) was subjected to various mordants, it developed various shades of brown. Cotton-jute mix (C3) sample showed dark yellowish brown colour with myrobalan, dark blackish brown colour with Ferrous Sulphate, Camel colour with Stannous Chloride and Yellowish brown with Potassium dichromate (Plate 4).

Herbal dyes being natural tend to be softer and their range of tones is very pleasant. At present total market of herbal dyes is to the tune of US $ 1 billion and is growing tremendously at the rate of 12% per annum. Per capita consumption of dyes is 400 g to 15 kg in developed and underdeveloped countries for their utility in paints, inks, textiles, polymers etc. India is a major exporter of herbal dyes mostly due to ban on production of some of the synthetic dyes and intermediates in the developed countries due to pollution problem[14].

The application of natural dyes in textile industry for various purposes, viz. dyeing of yarns, which are then woven into cloth, carpet or any other usable form; dyeing of cloths woven earlier; block printing, where the textile materials are printed with the help of printing blocks; Kalamkari where the “Kalam” or pen is used to draw beautiful designs on the cloth[15].

Natural dyes are now a days in demand not only in textile industry but in cosmetics, leather, food and pharmaceuticals. The rich biodiversity of our country has provided us plenty of raw materials, yet sustainable linkage must be developed between cultivation, collection and their use.

The present work shows that these flowers can be used as dye quite efficiently and commercially[8,14,16,17]. We can get different shades of colour using different mordants and the colour fastness, wash fastness properties also can be improved by different treatment procedures and so it is employed throughout India for dyeing silk and fabrics on a commercial scale. The solar drying, soap washing and heating did not alter the colour shade developed during the dyeing process i. e. colour, light and wash fastness. This colour dye has no side effect on skin and it has no harmful effect on environment also. The process is economically viable as the raw materials are available at low cost and so cost of production is also very low. Similar findings were reported in Marigold, China rose and Bixa flower[3,8,14,17,18].

The flowers, which contain much of tannin, are Flame coloured and yield red/pink/brown/flame coloured shades of dye (depending upon the fabric used) in large amounts, therefore, utilized throughout India for dying silk and fabrics on a commercial scale. Dye extracted from *W. fruticosa* is exploited particularly, in perfume, leather and textile industry and believed to be superior for woollen and silk fabrics[14]. Many tribes of Arunachal Pradesh have been using this plant species traditionally in combination with other plants for extraction and preparation of dyes utilizing indigenous processes[8]. The blossoms are gathered during February-April and dried. The dye is prepared by steeping the flowers in cold or hot water. Alum or lime is added to this solution as a mordant, though in several parts of India dyeing is done without the mordants. The material to be dyed is immersed in this solution several times until a pink colour of desired depth is obtained. The twigs and leaves are also used in dyeing. The present study deals with the extraction of natural dye from *W. fruticosa* and their application on textiles. The literature reveals the chemical composition of the different parts of *W. fruticosa*[16,19-22], but no report exist so far on the extraction of natural dyes from this plant species and their applications.

Natural dyes have poor to moderate wash and light fastness as compared to synthetic dyes having moderate to excellent colour fastness properties. Light fastness of many natural dyes, particularly which are extracted from flower parts are found to be poor to medium[23]. Poor light fastness of some of the natural dyes is attributable to photooxidation of the chromophore. Such photooxidation can be prevented / minimized by forming complex of the dye with transition metal. To improve the wash and light fastness of these dyed cotton fabrics, the dyed cotton fabrics should further be treated with selected cationic dye-fixing agents and also with an UV-absorber compound, respectively. Natural dyes can be used on most types of material or fibre but the level of success in terms of fastness and clarity of colour varies considerably. Natural fibres come mainly from two distinct origins, animal origin or vegetable origin. Fibres from an animal origin include wool, silk, mohair and alpaca. Fibres of plant origin include cotton, flax or linen, ramie, jute, hemp and many others. It is found that natural dyeing of certain plant based textiles can be less successful than their animal equivalent. So, an extensive work has been carried out to improve the light fastness properties of different natural dyed textiles[23-26]. To obtain varying colour/shade, to increase the dye uptake and to improve the colour fastness behaviour of any natural dye for the future line of work, it can be suggested that different types and selective mordants or their combination can be applied on the textile fabrics or some natural vegetable fixing agent can be used. Many investigations revealed that the use of combination of mordants in varying ratios gives different shades and different colour fastness results[1]. Also, it is found that gamma irradiation can improve the dyeing characteristics and colour fastness properties from fair to good and so can be applied in future[27].

Conclusion

With the modern phases of development, dyes have become the most important resources, owing to their multifarious utilization, including an emerging branch of medicine i.e., Chromotherapy which greatly depends on natural colouring dyes. Usually, methods of collection and extraction of dyes are still crude and traditional with only a few experts related to cottage industries being well versed with dyeing procedures. As such, plenty of materials are improperly exhausted in the procedure. Therefore, proper utilization requires understanding of sustainability as well as specific preference of use pattern. Indigenous traditional knowledge on various resources including

dye yielding plants is very essential for rural based development and future bioprospecting, provided proper precautionary measures are considered for sustainability, conservation and value based selection of use pattern.

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