ORANGE DYE FROM *PYCNOPORUS* SP. FOR TEXTILE INDUSTRIES

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ABSTRACT

Colour plays a vital role in life of each and every one through industries like textiles, paint, food, clothing, art and cosmetics. The traditional natural dyes from plants were quickly replaced by synthetic dyes ever since the discovery of synthetic organic dye, mauveine by William Henry Perkin in 1856. Thousands of synthetic dyes have been prepared with several advantages like low cost, vast range of new colours and ability to impart better properties upon the dyed materials. Pigments from microbes especially fungi are considered as a good alternative to hazardous synthetic dyes. The work deals with orange dye from *Pycnoporus* sp. and its application as mushroom dye for textile industries. The work was initiated with isolation, followed by production of dyes from mycelial culture, simple and cost effective cultivation with successful fruiting body production, and extraction of dyes. It was followed by application of the mushroom dyes with cotton and silk yarns and fabrics. Pilot scale cultivation was successfully carried out and dyeing experiments were carried out at an industry for testing its suitability as natural dye.

Key words: *Pycnoporus* sp. dyes, textiles

INTRODUCTION

Color is the most pleasing attribute of any article; red color exudes warmth, increases pulse rate and respiration, whereas, blue or green color suggests cool and peaceful environment and encourages relaxation [1]. Although structurally very diversified and derived from a variety of sources, natural colorants can be grouped into a few classes, the most important of which are: anthocyanins, anthraquinones, tetrapyrrols, tetraterpenoids and flavonoids. The terms “pigment” and “dye” are often used interchangeably. After the accidental synthesis of mauveine by Perkin in Germany in 1856 and its subsequent commercialization, coal-tar dyes began to compete with natural dyes.

Synthetic colors became popular because of their fastness, wide range of colors, low cost even at high concentration in low volumes [2]. During the textile dyeing process up to 40% of dyes may remain unfixed to the fibre and act as contaminant in the industrial wastewater. It is known that 90% of reactive dyes entering activated sludge sewage treatment plants will pass through unchanged and be discharged into rivers [3]. They are very stable and difficult to degrade. These dyes are resistant to microbial attack and are hardly removed from effluents by conventional biological, physical or chemical treatments [4, 5].

Textile industry is the major consumer of dyes and the international market potential for textile dyes is US$ 10 billion. The potential for colorants and intermediates is US$ 24 billion of which dyes and pigments constitute $17 billion (71%) and dye intermediates $7 billion (29%). China is the major player with 25% share in production of dyes and India with 7-8% in global trade, which is expected to become 10% in a few years. India and China are the net exporters of dyes as they consume less than what they produce. China is robust in producing dyes since domestic consumption is 60-70% while exports are 30 - 40% and it is converse with India consuming 30-40% in domestic market and exporting 60-70% [6].

The biosphere is under constant threat by the textile dyeing industries due to release of environmental pollutants. Considerable research work is being undertaken around the world on the application of natural dyes. The industries are continuously looking for cheaper, more environment friendly routes to existing dyes in order to minimize the damage to the environment [7-9]. It has been well known that a variety of plants, animals and microorganisms produce pigments [10-13].

Natural dyes are derived from naturally occurring sources such as plants (eg., indigo and saffron), insects (eg., cochineal beetles and lac scale insects), animals (eg., some species of mollusks or shellfish), minerals (eg., ferrous sulfate, ochre and clay) and from variety of microorganisms [14-27].

The fruit bodies of some macromycetes/mushrooms (e.g., agaric) have been used less but they can produce a range of pink, blue, yellow, red, and brown (boletol blue) *Boletus luridus, Cortinarius* spp, *Hydnellum* spp. and *Hygrocybe* spp.) using mordant such as alum or iron [28].

In 1974, Miriam C. Rice published the first book concerning dyeing with fungi and since then, the custom has spread all over the world. *Laetiporus sulphureus* (Bull.: Fr.) Murr. (Polyporales, Fungi) is a wood rotting basidiomycete growing on several tree species and producing shelf-shaped fruit bodies of pink-orange colour, except for the fleshy margin which is bright yellow. *Laetiporus* species contain a number of lanostane triterpenoids and other metabolites and has a great industrial application in food, textiles industry [29-30]. Extraction of anthroquinone dyes from a Polyporaceae member *Dermocybes anguineus* showed potential dyeing properties on different fabric materials [31].

An orange pigment from the fungi *Ganoderma applanatum, Coriolus versicolor* and *Amanita muscaria* was extracted from the basidiocarp and applied on the silk and cotton fabrics [20].The cost effective method of cultivation of *Ganoderma lucidum* and application of its dyes to cotton and silk yarns were done and the dyed yarns showed good fastness tests [22]. Cost effective method of cultivation of *Pycnoporus sanguineus* and application of its dyes to cotton and silk yarns and fabrics was done and tested up to industrial level [27].

Pycnoporus is a slow-growing saprophytic fungus belonging to the class Basidiomycetes of the family Polyporaceae. It is a known white-rot fungi of wide occurrence in tropical and subtropical countries. It grows on decaying logs and tree stumps, which causes decay of certain types of wood in the forests of tropical and subtropical areas [32-34].

Pycnoporus is being intensively studied because of the metabolites produced by it and reported to synthesize some substances with medical applications [35-36], and to produce various enzymes of industrial applications such as invertase [37], tyrosinase [38], α-amylase [39], xylanase and β-glucosidase [33] and laccase [34]. Among the enzymes produced by *Pycnoporus*, laccase is of particular interest because of its effectiveness in numerous biotechnological applications [40]. The laccase secreted by *Pycnoporus* has demonstrated its ability on the decolourization of azo and triphenyl methane dyes [41].

The work was initiated with isolation, followed by production of dyes from mycelial culture, simple and cost effective cultivation with successful fruiting body production, and extraction of dyes. It was followed by application of the mushroom dyes with cotton and silk yarns and fabrics. Pilot scale cultivation was successfully carried out and dyeing experiments were carried out at an industry for testing its suitability as natural dye.

MATERIALS AND METHODS

Pycnoporus were inoculated on PDA medium for a period of 7 days for the development of pure culture. The mycelial disc (2 mm in diameter) of *Pycnoporus* was inoculated at the centre of the petriplate containing 20 ml of medium and incubated at 30±2 °C. Optimization studies like pH and temperature were undertaken for the successful production of dyes [27].

Pycnoporus was subjected to spawn development using different substrates such as sorghum grains, maize grains, paddy husk, combination of maize grains with paddy husk (1:1) and sorghum grains with paddy husk (1:1).The locally available lignocellulosic wastes substrates such as sugar cane bagasse, saw dust, paddy straw and wood shavings were collected from the surrounding places and brought to the laboratory. The collected substrates were transported to the laboratory and shade dried. The infected or contaminated parts of the substrates were discarded and healthy lignocellulosic substrates were further processed for mushroom beds preparation and maintained [27]. Standardization of various parameters was done for the successful cultivation and the biological efficiency was calculated.

Various extraction procedures using different polar and nonpolar solvents were followed and the pigment was extracted. Cotton and silk fabric was treated with alum, tannic acid and dyed with the dyes of *Pycnoporus*. The wash fastness of the fabric was recorded.

RESULTS AND DISCUSSION

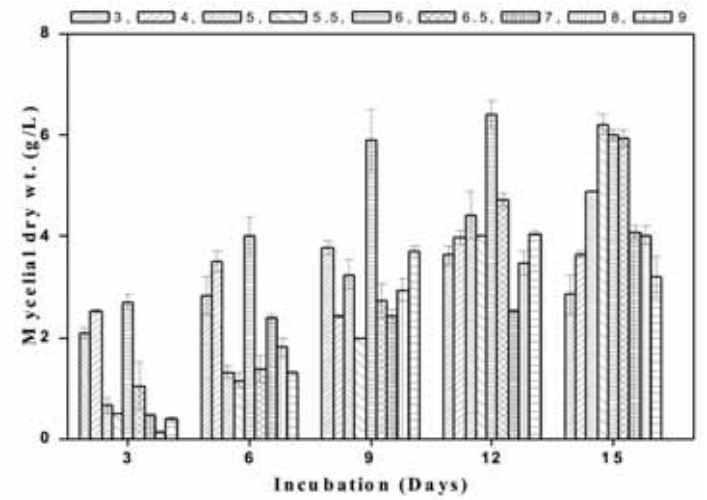

Figure 1. Optimization of growth (dry wt) of *Pycnoporus* in PDB at various pH

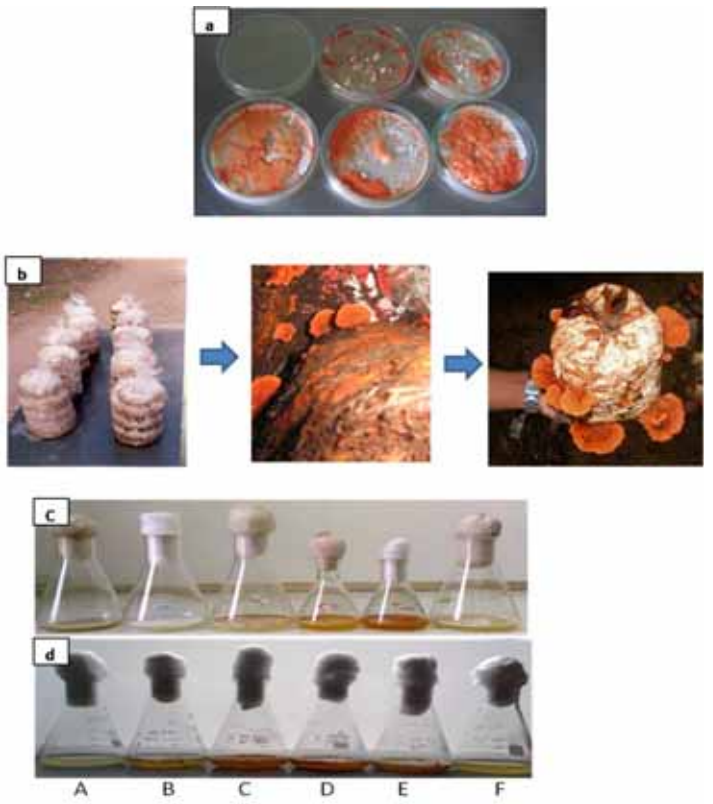

Plate 1. Production of *Pycnoporus* on solid and liquid media **a)** Growth of *Pycnoporus* in solid media; **b)** Cultivation of *Pycnoporus* in locally available lignocellulosic substrates; **c and d –** Optimization of *Pycnoporus* at Various pH and temperature; **c** - A – PDB Control, B - pH 3, C - 4, D - 5, E - 6, F -7; **d** -A - PDB Control, B - 20, C - 25 , D - 30, E - 35, F – 40 !

Pycnoporus mycelium was grown on PDA medium for a period of 7 days (Plate 1a). The mycelial growth of *Pycnoporus* was studied in PDB medium maintained at pH 3.0, 4.0, 5.0, 5.5, 6.0, 6.5, 7.0, 8.0 and 9.0.The pH had influence on growth of *Pycnoporus***.** The maximum mycelial growth (6.42 ± 0.2 g dry weight/l) was recorded on PDB at pH 6.0 on 12thday (Fig.1). The mycelial growth of *Pycnoporus* significantly reduced at pH 8.0 to 9.0. The pH 6.0 and temperature 30 °C was found to be optimum for the growth of *Pycnoporus* (Plate1 c, d).

Mycelial spawn development of *Pycnoporus*on maize grains initiated on 3rd day after inoculation.The mycelium densely colonized maize grains within 20 days as compared to other substrates which required 30 days. The optimum temperature for spawn growth was 25±2 °C.

Locally available lignocellulosic agriculture residues such as paddy straw, sugar cane bagasse, saw dust and wood shavings were individually utilized as substrate for cultivation of fruiting bodies of *Pycnoporus*. The mycelial growth started on 2nd day and complete mycelial colonization was recorded on 12th day of incubation. The appearance of pin heads and the matured fruiting body of *Pycnoporus* is shown in Plate 1b. Successful pilot scale cultivation was carried out using simple and cost effective cultivation methods. The research finding revealed that *P. cinnabarinus* can be cultivated successfully on different substrates like wheat straw, saw dust, bird seeds and wheat flour [42]. Wild fruit body of *P. cinnabarinus* was collected from the Coorg region in western ghat. The spawn was prepared on sorghum grains and substrate (saw dust in combination with wood chips) supplemented and successful cultivation was reported [43].

Successive pigment was extracted using simple, cost effective methods and the fruiting bodies of *Pycnoporus* and the recovered dye was applied to treated cotton and silk fabrics. Control fabric was maintained without any treatment and also fabrics dyed without any mordant treatments recorded fair to good wash fastness properties (Plate 2 a & b).

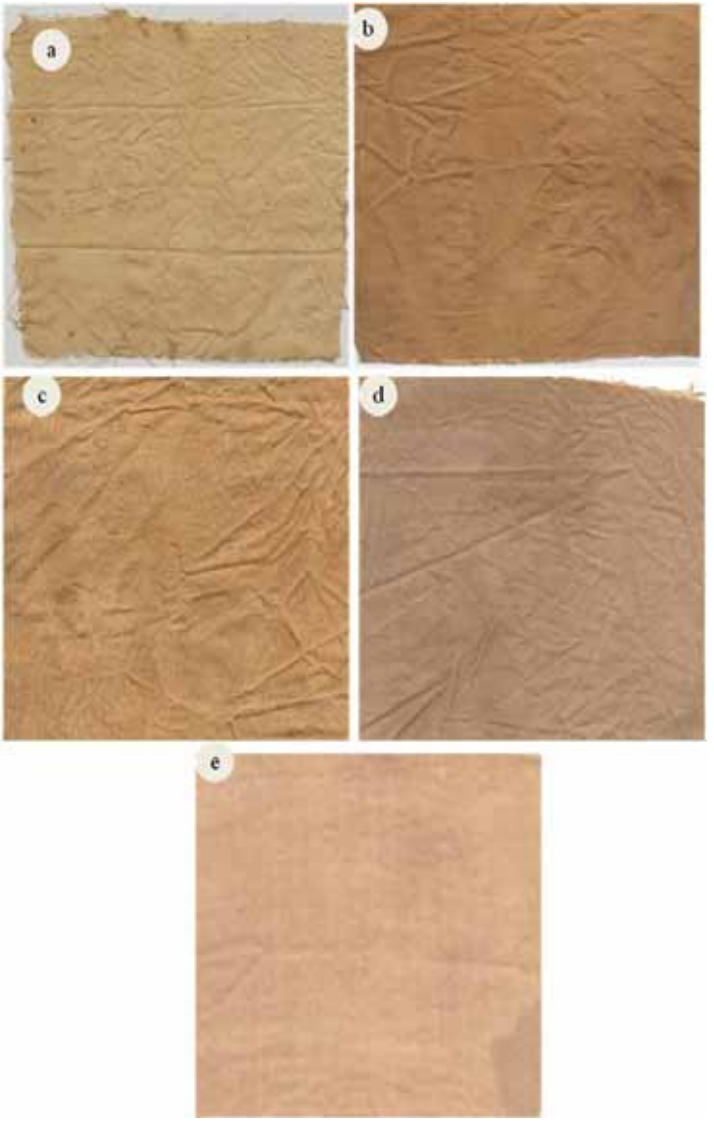

Plate 2a. Dyeing of cotton fabrics with *Pycnoporus* pigment premordanted with alum and tannic acid. **a)** Cotton + Alum +Pigment, **b)** Cotton + Tannic acid +Pigment, **c)** Cotton + Alum + Tannic acid +Pigment, **d)** Cotton + Alum + Tannic acid +Pigment + water washed, **e)** Cotton – Alum + Tannic acid +Pigment + soap washed

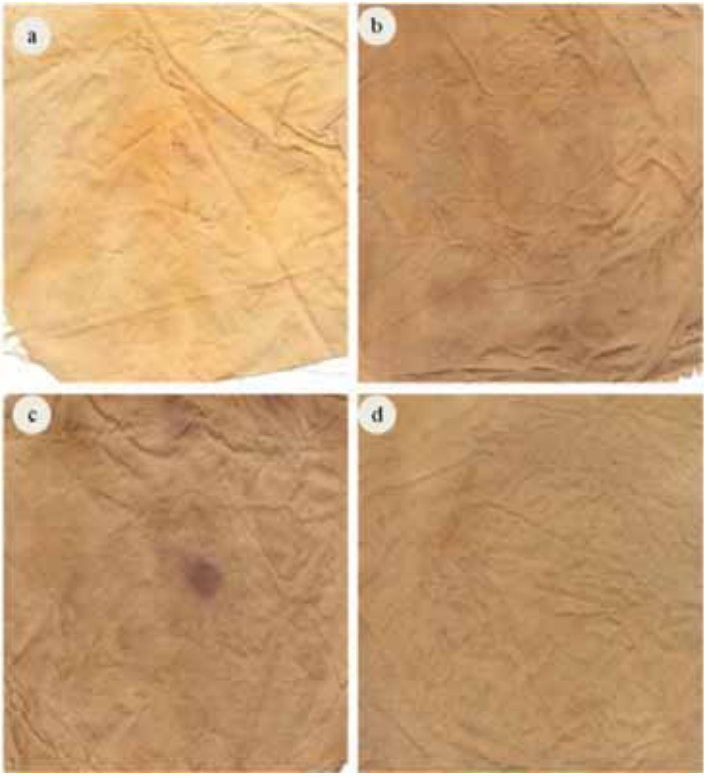

Plate 2b. Dyeing of silk with pigment of *Pycnoporus* premordanted with alum and tannic acid. **a-** Alum +Pigment, **b-** Tannic acid +pigment, **c-** Alum+ tannic acid+ pigment, **d-** Alum+ tannic acid+ washed

CONCLUSION

The work highlights the experience with the orange dye from *Pycnoporus* sp. and its application as mushroom dye for textile industries. Many interesting results were obtained and it is hoped that at least some of them will find applications in the future.

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