



Development of Direct Printing Paste for Silk Printing and its Efficacy for Colour Fastness

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ABSTRACT

Background: Concerns over the environmental and health hazards of using synthetic dyes, resulted in growing interest of using natural resources in textile printing sector. The artisans use different techniques and methods based on the availability of natural sources.

Methods: The present study explores the effectiveness of guar gum and tamarind seed powder (TSP) as natural thickening agents in developing eco-friendly print pastes for silk fabric using natural dyes. Six print paste combinations were formulated using annatto, arjuna and madder dye along with auxiliaries such as chitosan, alum, coconut oil and myrobalan. The natural dye was extracted by aqueous extraction method followed by ultra-sonication of the dye extract.

Result: The results revealed that guar gum-based combinations exhibited superior design quality compared to TSP. Among all samples, the combination containing arjuna dye with guar gum (PPC 02) achieved the highest mean score (4.53) followed by annatto with guar gum (PPC 01). Whereas, TSP combinations with annatto and arjuna showed poor performance while the madder dye combination (PPC 06) demonstrated better results comparable to guar gum.

Key words: Guar gum, Natural dyes, Natural printing auxiliaries, Screen printing, Tamarind seed powder.

INTRODUCTION

In India, natural dyes have been used for thousands of years to print and dye fabrics. With incredibly advanced printing and decorating techniques, India has an extensive and diverse past in the textile industry. Madder, Tesu flowers, Indigo, Turmeric, Annatto, Morinda, Henna, Sappan wood, Barberry and other natural dyes were once often utilized as textile colorants (Uddin *et al.*, 2022). However, consumers quickly moved toward synthetic dyes after they were developed because of their affordability, accessibility, variety of colors and consistency and good fastness qualities (Savvidis *et al.*, 2017). Instead, some areas across the world continued to employ natural dyes in the textile industry for dyeing and printing. However, over the past few decades, the use of synthetic dyes has been steadily declining due to growing environmental awareness and adverse effects resulting from their toxicity or non-biodegradable nature. Natural dyes, meanwhile, have begun to gain prominence again in the textile dyeing and printing industries due to their non-toxic and environmentally friendly nature (Gargi and Srivastava, 2023).

Both large and small textile manufacturers are now investigating natural sources for dyeing and printing textiles in a sustainable manner (Sangamithirai, 2023). Dyeing and printing is the process of colouring the textile substrate like fibres, yarn or fabric with the dyes to enhance the aesthetic value of fabric. In dyeing process, the whole fabric is covered uniformly with one or more colours while in textile printing one or more colours are applied in a predetermined pattern (Abdelrahman, 2020). Textile printing methods are traditionally divided into two categories: Direct

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printing and indirect printing. While resist printing and discharge printing are examples of indirect printing processes, block printing, screen printing, digital printing and other direct printing methods are the most often used (El-Kashouti, 2019).

Printing auxiliaries, such as thickeners, fixing agents, etc., were required with combinations of dye materials in order to produce print paste with improved color fastness properties along with distinct and sharp designs (Panda, 2013). Thickeners, which are high molecular compounds used in textile printing to offer printing paste stickiness and flexibility, are an essential component. Mordants is used as an agent that helps to make bond between natural dye and fabric to enhance fastness properties whereas fixing agents were also incorporated in the print paste to

improve the washing, perspiration and sunlight fastness of the printed fabrics (Gargi and Srivastava, 2023).

Mansour and Ben Ali (2023) investigated the use of chitosan as sustainable agent to improve dyeing properties of cotton fabric dyed with *Opuntia ficus-indica* L. fruit. Experimental results revealed that the fastness properties of dyed cotton fabrics were improved from average to excellent after treated with chitosan. Chattopadhyay *et al.* (2018) conducted an experiment on the bleached and scoured jute fabric, double-mordanted with potash alum and myrobalan. By using aqueous extraction process, natural dyes were extracted from ratanjot bark, manjistha roots and annatto seeds. The results show that by using a substantively screen-printing technique, printed jute cloth exhibits excellent wash and rub fastness with all three natural dyes with combinations of natural thickening agent guar gum. Divya *et al.* (2019) conducted a study on screen printing of regenerated cellulosic fabric-lyocell. The printing paste prepared with dye extracted from natural sources *i.e.* madder and katha by using various ratio of guar gum and chitosan. Results showed that both the dyes showed moderate to good light fastness and excellent wash fastness. A study was conducted by Gargi and Srivastava (2024) formulate printing paste using two natural dyes madder and arjuna along with thickening agent guar gum powder, fixing agents chitosan, two mordants myrobalan and alum and cold pressed coconut oil as plasticizer to develop direct prints on cotton fabric. The screen printed cotton fabric samples exhibits very good to excellent colour fastness properties and the developed prints was found highly acceptable among consumers for use as home textiles.

Though the use of natural dyes in the dyeing industry has become more prevalent in India, there has been limited application and research on natural dyes and printing auxiliaries. Natural dyes can be used for printing but synthetic mordants, thickeners and binding agents were utilized to produce print paste. Hence, there is need to be focussed on the natural printing auxiliaries along with natural dyes for textile printing. To develop direct prints with enhanced fastness properties, the study was conducted on printing of silk fabric using natural dyes and printing auxiliaries.

MATERIALS AND METHODS

Silk degumming

The process of degumming of silk fabric were carried out in order to increase the fabric absorbency as well as to achieve uniform printing and proper penetration of printing paste.

Selection of natural dyes and printing auxiliaries

In order to develop eco- friendly prints on silk fabric three natural dyes Annatto, Arjuna and Madder were selected. The natural printing auxiliaries like guar gum and tamarind seed powder as thickening agents, chitosan liquid as fixing agents, myrobalan as mordant and coconut oil as plasticizer were selected for the study.

Preparation of printing paste

The dye extract used to develop print paste was extracted by aqueous method followed by the ultra-sonication of the dye extract. The print paste is developed using the combinations of dye extract and printing auxiliaries *i.e.* guar gum powder and tamarind seed powder, myrobalan, chitosan and coconut oil. The mordants were directly incorporated in the print paste. The standardized recipe was used to develop print paste combinations.

The print paste combinations developed are as follows-

Guar gum combinations

Combination 01: (Annatto + Guar gum + Chitosan + Alum + coconut oil + Myrobalan).

Combination 02: (Arjuna + Guar gum + Chitosan + Alum + coconut oil + Myrobalan).

Combination 03: (Madder + Guar gum + Chitosan + Alum + coconut oil + Myrobalan).

Tamarind seed powder (TSP)

Combination 04: (Annatto+ TSP + Chitosan + Alum + coconut oil + Myrobalan).

Combination 05: (Arjuna + TSP + Chitosan + Alum + coconut oil + Myrobalan).

Combination 06: (Madder + TSP + Chitosan + Alum + coconut oil + Myrobalan).

Printing on the fabric

Screen printing technique was adopted for the study to develop direct prints on degummed silk fabric. The silk fabric was then printed by using combinations of developed print paste. For screen printing, the suitable amount of developed direct print paste was poured on the screen mesh and with the help of squeegee the print paste was transferred on the fabric.

After treatment

The screen-printed samples were then dried, fixed by steaming process and rinsed in cold water. The developed samples were assessed for subjective and objective evaluation on various parameters.

The samples printed with annatto dye combinations exhibits orange color shade, arjuna dye combination printed samples gave shades of brown whereas madder dye combination showed dark reddish shade as showed in Fig 1.

RESULTS AND DISCUSSION

The printed samples were evaluated by subjective evaluation on various parameters like depth sharpness and uniformity of design and for colour fastness to washing, rubbing and light.

Subjective evaluation

For subjective evaluation, a panel of ten experts assessed the printed samples on selected parameters such as depth

of shade, uniformity of design and sharpness of design. The 5 point rating scale were used to evaluate the printed samples. The mean score obtained by the samples are shown in Table 1.

It was found that samples printed with Guar gum combinations *i.e.* PPC 01 and PPC 02 gave best result with the mean score 4.47 and 4.53 respectively whereas PPC 03 gave mean score 3.93 on silk fabric. Best results obtained by guar gum combination on annatto and arjuna dye.

Whereas samples printed with tamarind seed powder combinations *i.e.* PPC 04 and PPC 05 gave poor result with the mean score 2.17 and 2.03 respectively whereas PPC 06 gave best mean score of 4.53 on silk fabric. Best results obtained by tamarind seed powder combination on madder dye.

Objective evaluation

By using standard test procedures, the samples were evaluated for the wash, rubbing and light fastness properties. Grey scale was used for assess the wash and rub fastness of the printed samples whereas blue wool

scale was used to assess the ligh fastness properties of the screen printed samples.

Fabric printed with Annatto dye combinations, PPC 01 and PPC 04 exhibits good to very good fastness for wash, rub and light fastness. Fabric printed with arjuna dye combinations, PPC 02 exhibits excellent light fastness and good to excellent wash and rub fastness on silk while PPC 05 exhibits poor colour fastness. In case of samples printed with madder dye combinations, the combination PPC 03 and PPC 06 exhibits good to very good fastness for wash, rub and light fastness. It can be concluded that the samples printed with Arjuna dye combinations gave best results with the combination PPC 02 on silk fabric with excellent light fastness (rated 8).

While considering thickening agents, from the Table 1 and 2, it can be concluded that when comparing the mean score and colour fastness values of the fabric printed by using guar gum and Tamarind Seed Powder. The guar gum combinations (PPC 01, PPC 02 and PPC 03) demonstrated superior design quality compared to tamarind seed powder combinations. Among these, PPC

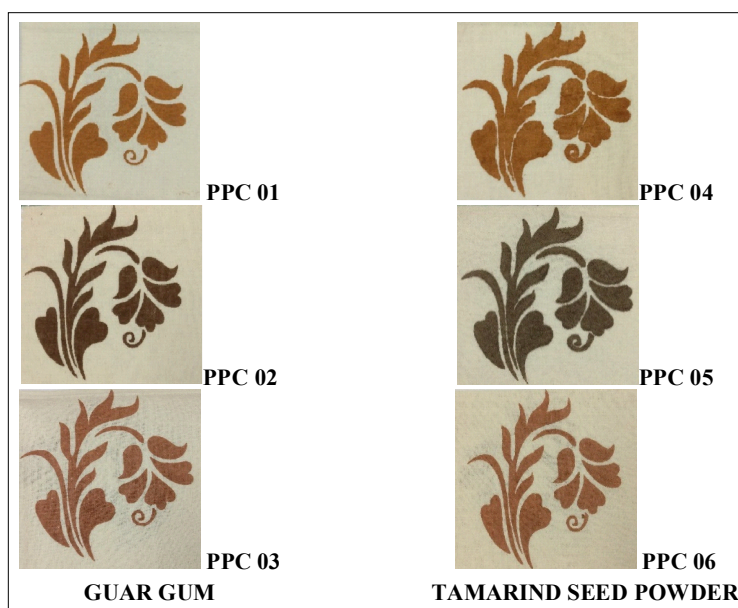


Fig 1: Development of prints on silk fabric with various natural dye and print paste combinations.

Table 1: Mean score obtained by the developed samples on various parameters.

Print paste combinations	Parameters			
	Uniformity	Depth of shade	Sharpness of design	Mean score
PPC 01	4.3	4.4	4.7	4.47
PPC 02	4.5	4.4	4.7	4.53
PPC 03	3.8	3.7	4.3	3.93
PPC 04	1.8	3	1.7	2.17
PPC 05	1.9	1.8	2.4	2.03
PPC 06	4.6	4.5	4.5	4.53

(*PPC- Print paste combination).

Table 2: Colour fastness of develop printed samples.

Print paste combination	Parameters				Light fastness
	Wash fastness		Rubbing fastness		
	CC	CS	Dry rubbing	Wet rubbing	
PPC 01	4	4	4	4	6
PPC 02	4	4/5	4	3	8
PPC 03	3	4	3	4	5
PPC 04	3/4	3/4	3	3/4	5
PPC 05	3	3	4	4	5
PPC 06	4	4	4	4	6

(Note- 1- Very poor, 2- Poor, 3- Good, 4- Very good, 5- Excellent, 6- Very good, 7- Excellent, PPC- Print paste combination).

02 (Arjuna dye) exhibited the highest mean score (4.53) indicating excellent uniformity, depth of shade and sharpness of design. PPC 01 (Annatto dye) also showed high performance with a mean score of 4.47, whereas PPC 03 (Madder dye) gave a comparatively lower mean score of 3.93. Meanwhile, the tamarind seed powder (TSP) combinations showed variable and comparatively lower performance. PPC 04 (Annatto dye) and PPC 05 (Arjuna dye) exhibited poor design quality with mean scores of 2.17 and 2.03 respectively indicating poor uniformity and sharpness. However, PPC 06 (Madder dye) demonstrated excellent performance with a mean score of 4.53 comparable to the guar gum combinations.

The guar gum combinations (PPC 01, PPC 02 and PPC 03) PPC 02 showed excellent light fastness (rating 8) and good to very good wash and rubbing fastness while PPC 01 exhibited consistently very good fastness properties. PPC 03 demonstrated moderate to good fastness across all parameters. Meanwhile, the tamarind seed powder (TSP) combinations, PPC 04 showed good results whereas PPC 05 exhibited relatively poor fastness properties. On the other hand, PPC 06 demonstrated good to very good wash, rubbing and light fastness. Overall, the findings suggest that guar gum as a more effective thickening agent, enhancing dye penetration, fixation and print clarity, particularly with annatto and arjuna dyes. Tamarind seed powder, although less effective in with arjuna and annatto dye but more effective with madder dye, resulting in improved design quality and fastness properties in PPC 06.

The similar findings were reported by Chattopadhyay *et al.* (2018) in which jute fabric printed with manjistha, annatto and ratanjot and guar gum exhibits very good wash and rub fastness. Similar findings were reported by Gargi and Srivastava (2024) that the screen printed cotton fabric exhibits very good to excellent colour fastness properties printed with annatto, madder and arjuna with combination of guar gum, myrobalan and chitosan.

CONCLUSION

Based on the results, it can be concluded that the performance of natural dye printing on silk fabric is significantly influenced by thickening agent and dye

combination exhibits better fastness properties and can be successfully used for developing eco-friendly prints on cotton fabric. Guar gum combinations exhibited superior overall performance, particularly in combination with annatto and arjuna dyes. Among all samples, PPC 02 emerged as the most effective, demonstrating the highest design quality and excellent light fastness.

Tamarind seed powder combinations showed inconsistent results, however, its combination with madder dye (PPC 06) yielded excellent outcomes comparable to guar gum. Therefore, results suggest that guar gum acts as an effective thickening agent, enhancing dye fixation and print clarity, particularly with annatto and arjuna dyes. These findings indicate that while tamarind seed powder is less effective overall compared to guar gum, it performs exceptionally well with madder dye.

Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

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