

Exploring Psyllium as a Natural Substitute for Synthetic Thickeners in Cotton Printing Applications

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Abstract

Psyllium is a bulk-forming laxative that is used for medicinal purposes, especially for treating constipation. This study explores the use of psyllium husk (*Plantago ovata*) as a natural and sustainable thickening agent for printing cotton fabrics with reactive dyes and pigments. The goal was to find an eco-friendly alternative to traditional thickeners, such as sodium alginate and carboxymethyl cellulose (CMC), which are often costly and less sustainable. Printing pastes were prepared with different concentrations of psyllium (5–50 g/L) and tested for viscosity, colour strength, softness, and fastness properties. The results showed that a concentration of 35 g/L provided the best performance, offering the right viscosity for smooth printing and sharp design outlines. Fabrics printed with psyllium at this level produced brighter colours (higher K/S values) and a softer feel compared to those printed with sodium alginate or CMC. Washing and rubbing fastness results were similar across all thickeners. Psyllium's natural negative charge prevents it from reacting with dyes, making it suitable for different classes of reactive dyes. Overall, psyllium proved to be an effective, affordable, and environmentally friendly alternative that enhances print quality while supporting sustainable textile production

Keywords: Psyllium husk, sodium alginate, carboxymethyl cellulose, reactive dyes, sustainable textile printing.

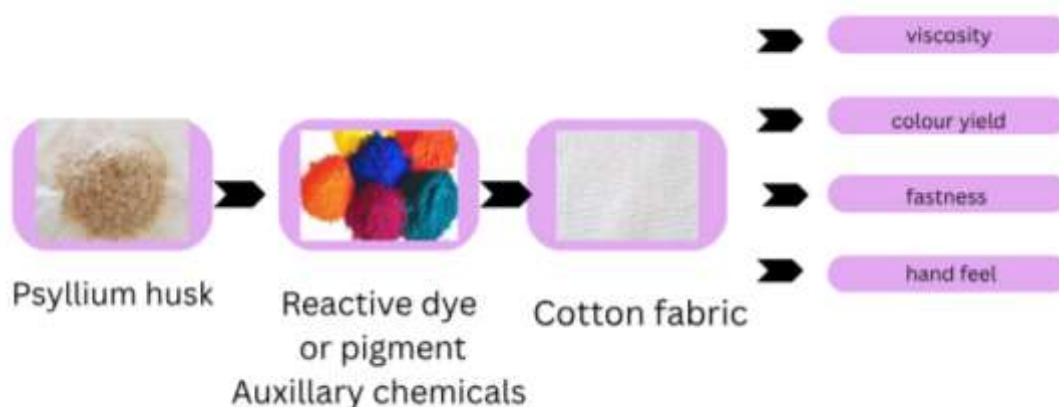


Figure 1. Graphical Abstract

1. Introduction

Textile printing is one of the oldest arts, with roots going back thousands of years, and it continues to evolve in step with new materials, technologies, and environmental concerns. In this fast-changing world, printing remains one of the most important methods used today for decorating textile materials [1]. Textile printing is a widely adopted coloration process that applies colorants only to selected portions of fabric, creating multicolored designs that enhance both the aesthetic and commercial value of textiles compared to plain-dyed materials [2]. Among various fibers, cotton occupies a central position in global textile printing, particularly in India, where printed cotton dominates the market over dyed cotton fabrics due to its visual appeal and high demand [3]. Reactive dyes are most commonly used for cotton printing because of their ability to form covalent bonds with cellulose under mild alkaline conditions, ensuring good fixation and wash fastness.

An essential component of printing is the thickener, which regulates the viscosity and rheology of the print paste. Thickeners serve two key functions: they allow uniform application of color to fabric surfaces and help maintain design sharpness by preventing the spreading of color pastes into adjacent regions [4]. The flow properties of printing pastes strongly influence print quality. Excessive viscosity can hinder processing and increase costs, while insufficient viscosity may result in poor edge definition and blurred designs [5]. Therefore, the selection of an appropriate thickening agent is critical for achieving high-quality prints.

Traditionally, sodium alginate and sodium carboxymethyl cellulose (CMC) have been the dominant thickeners in cotton printing with reactive dyes. While sodium alginate is effective in preventing unfavorable dye-thickener interactions, its high cost, limited availability, and dependence on seaweed resources pose major challenges to sustainability [6]. Similarly, CMC, although widely used due to its solubility and thickening efficiency, suffers from drawbacks such as poor compatibility with certain reactive dyes, inconsistent viscosity under alkaline conditions, and the generation of high chemical oxygen demand (COD) in wastewater [7]. Overreliance on these thickeners therefore not only increases production costs but also exacerbates environmental concerns related to effluent treatment and resource scarcity. However, the widespread use of synthetic thickeners in printing has several disadvantages: they often contribute to environmental pollution, may be toxic or allergenic, and their manufacture and disposal can have harmful effects. To reduce these adverse impacts, environmentally friendly natural thickeners are being explored. Natural thickeners, being widely available from plants and plant by-products, are abundant and renewable. Because their components are derived from nature, they are generally non-toxic, non-allergenic, and pose little risk to human health. Research has shown that natural gums (e.g. neem, almond, arabic gums), fruit-peel derived pectin, modified xanthan, etc., deliver promising performance in textile printing, offering good color fastness, rheological properties, and reduced environmental impact compared to many synthetic alternative [2].

This study highlights eco-friendly natural alternatives as a step toward sustainable textile printing. Plant-derived gums and polysaccharides are attractive substitutes due to their biocompatibility, low toxicity, biodegradability, and cost-effectiveness compared to synthetic polymers [7]. Among various candidates, psyllium husk (Isabgol), obtained from *Plantago ovata*, has emerged as a promising thickener for textile printing applications. Psyllium polysaccharides are anionic, abundant, and possess desirable properties such as easy availability, low allergenicity, and the ability to form viscous gels suitable for printing pastes [8]. Furthermore, psyllium husk demonstrates good compatibility with reactive dyes, offering a sustainable and environmentally responsible alternative to conventional thickeners [6,9].

In light of these considerations, the present study investigates the use of natural gums, particularly psyllium husk, as thickeners in reactive dye printing of cotton fabrics, aiming to achieve sustainable printing without compromising print quality.

2. Experimentation

2.1 Materials Required

Commercially bleached, mercerized and unfinished plain weave cotton fabric with following specifications was used for printing: count- warp 20^s, weft 20^s; ends per inch, 66; picks per inch, 68; fabric weight, 242 g/m² all of which were procured from local industries with quality certificate.

Table 1. Materials Required

Material List	Specification	Sourced Industries
Reactive dyes	Remazol Red RGB, Levafix Red CA-N, Procion Red PX-8B	Dystar, India
Pigment dye	Imperon Red K3BL	Dystar, India
Chemicals (lab grade)	Urea, Sodium carbonate, Sodium bicarbonate, Liquid ammonia	Merck Specialties Pvt. Ltd.
Auxiliaries (commercial grade)	• Sera Con M-LU (oxidizing agent) • Sera Gal RM (fixation accelerator) • Sera Fast M-LF (cross-linking agent) • Sera Soft M-SW conc (softener) • Sera Binder M-HFT (binder) • Sera Sperser CSN (soaping agent)	Dystar, India
Thickeners	• Sodium alginate (lab grade) • Carboxymethyl cellulose (CMC, lab grade) • Psyllium husk (commercial food grade, ground to powder)	Sidhpur Isabgol Processing Company, India

2.2 Methodology

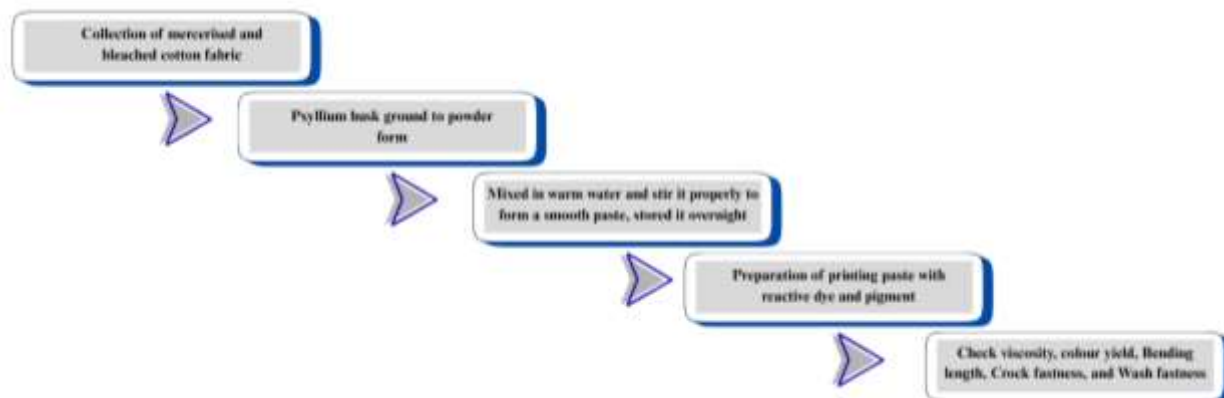


Figure 2. Methodology

2.3 Material Preparation

2.3.1 Preparation of Thickener Stock Paste: Thickener powder was dispersed in warm demineralized water under continuous mechanical stirring until a homogeneous paste was obtained and stored overnight[10].

2.3.2 Preparation of dye Paste (Reactive Dye Printing) : Urea was dissolved in warm water and cooled to room temperature. Reactive dye and auxiliaries (excluding alkali) were added and stirred to form a uniform paste, into which the calculated amount of thickener stock paste was incorporated. Alkali was added immediately before printing. Table 2.

Table 2. Printing paste composition for reactive dyes

Constituent	Concentration
Dye	4%
Urea	5%
Psyllium/ sodium alginate / CMC	X [#] / 8 / 8 (%)
Sodium Bicarbonate	3%
Soda ash	0.2%
Sera Con M-LU	3%
Water	To make the paste volume 100 gms

2.3.3 Preparation of Pigment Paste: Urea and auxiliaries (excluding cross-linking agent) were dissolved in warm water and cooled. Pigment and the calculated amount of thickener stock paste were incorporated, followed by thorough stirring. The cross-linking agent was introduced just before printing.

2.3.4 Printing of Fabric: The prepared pastes were applied onto cotton fabric using the flat screen printing method. Reactive dye prints were dried at 90 °C for 5 min, steamed at 102 °C for 15 min, washed with 2 g/L Sera Sperse CSN at 60 °C for 15 min, rinsed (warm and cold), and finally dried at 90 °C for 5 min. Pigment prints were dried at 90 °C for 5 min, cured at 150 °C for 3 min, washed, rinsed, and dried under the same conditions.

2.3.5 Printing with pigment

2.3.5.1 Preparation of printing pastes

Cotton printing with pigment was carried out using the following printing components as shown in table 3.

Table 3: Printing paste composition for pigment

Constituent	Concentration
Imperon Red K3BL	4 %
Liquor Ammonia	0.2 %
Urea	3.0 %
Sera Gal RM	0.2 %
Sera Binder M-FHT	8-16 %*
Sera Soft M SW Conc.	0.5%
Sera Fast MLF	1.0 %
Psyllium/ sodium alginate/ CMC	X [#] / 8/ 8 (%)
Water	To make the paste volume 100 gms

2.4 Evaluation of Printed Samples

Colour yield and colour difference were determined by measurement of K/S values and dE (on Datacolor SF 600) at the λ_{max} under D65 illuminant. Bending length of the treated samples was tested as per ASTM (E290-09). Colour fastness of the treated samples was evaluated as per AATCC 116. Washing fastness of the treated samples was evaluated as per AATCC 61 [11].

3. Results and Discussion

3.1 Viscosity of the Print Paste

The thickness (viscosity) of the thickener solutions was measured at 25 °C using a Brookfield Viscometer (Model RVF) set at a shear rate of 12 s⁻¹. Viscosity was calculated from the relationship between the force applied (shear stress) and the speed of flow (shear rate) [12].

3.2 Viscosity of the print paste

Figure 3 shows the results for the viscosity of the psyllium at different concentrations varying from 5 to 50 g/l.

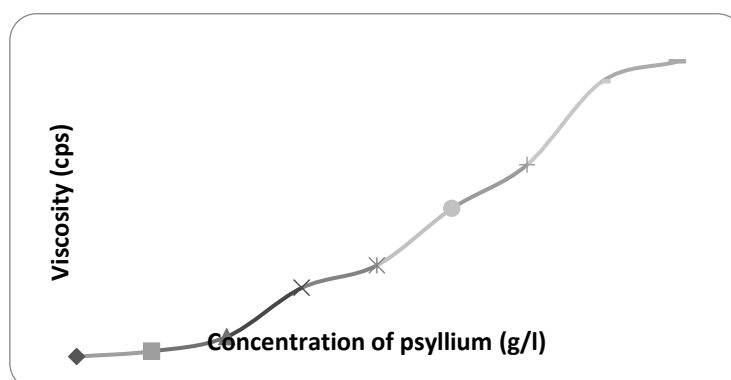


Figure 3. Viscosity of psyllium at different concentrations

From the above results, it was observed that viscosity at concentration below 20 g/l was very low and might not provide the proper rheology for the printing paste for sharp prints. At concentration of 30 g/l and 35 g/l, the viscosity was found adequate i.e. 5750 and 7400 cps (centipoises) respectively. Viscosity at concentration higher than 35 g/l was found quite high i.e. 10550 cps at 40 g/l and 11300 cps at 50 g/l.

3.3 Colour Yield

For the optimization of the psyllium's concentration as a thickener, remazol red RGB (based on vinyl sulphone) was used as a reactive dye. Figure 4 shows results of the colour yield in the terms of K/S at $\lambda_{\max}$ 530 nm for samples printed with varying concentration of psyllium from 20 g/l to 50 g/l.

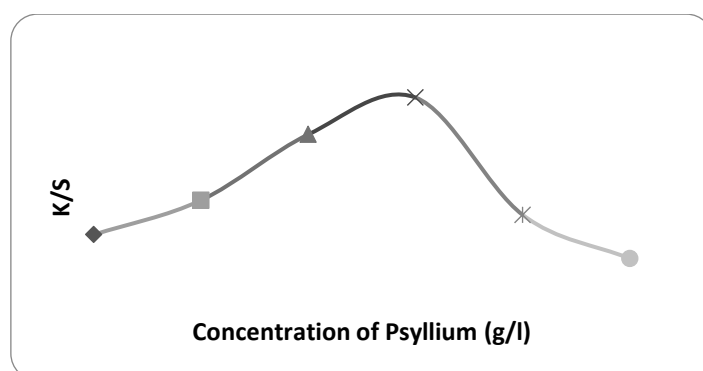


Figure 4. K/S values of printed samples at different concentration of psyllium

The result indicates that with the increase in the psyllium concentration, K/S increased up to the concentration of 35 g/l i.e. 17.89 at 20 g/l, 18.45 at 25 g/l, 19.52 at 30 g/l and 20.12 at 35 g/l. With further increase in thickener concentration, K/S values decreased i.e. 18.21 at 40 g/l and 17.5 at 50 g/l. This may be attributed to the higher paste viscosity leads to poor transfer of the colour yield on the fabric [13].

The samples printed with conventional printing thickeners like sodium alginate and CMC provide colour yield in terms of K/S as 14.29 and 13.59 at 80 g/l each respectively which were found lower than the samples printed with Psyllium at all concentrations [14].

3.4 Bending Length

Figure 5 shows the results for the bending length of the samples printed with varying concentration of psyllium from 20g/l - 50g/l.

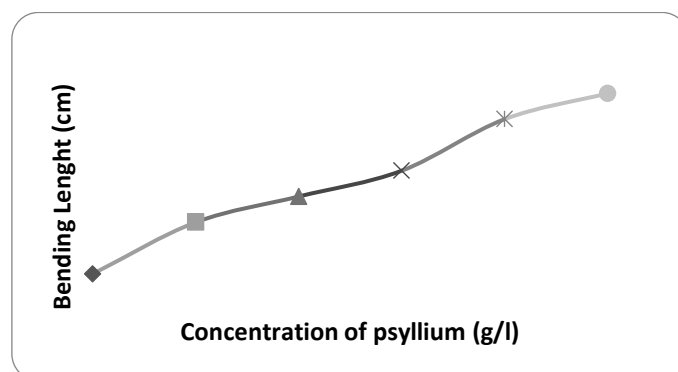


Figure 5. Bending length at different concentration of psyllium

The bending length of the samples increased with the increase in the concentration of thickener having a

least value of 1.8 cm at 20 g/l and highest value of 2.5 cm at 50 g/l. It may be attribute due to increase in the concentration of the Psyllium husk on printed fabric leads to decrease in the softness of the fabric [15]. Bending length of the samples printed with conventional thickener like sodium alginate and CMC was found to be 3.7 cm and 3.4 cm respectively and found comparatively higher than the sample printed with psyllium which concludes that new thickener provides softer hand feel to printed fabric than conventional thickeners. This may be attributed to the low concentration usage of psyllium on the fabric for printing. From the results of viscosity, colour yield and bending length, it was found that printing with psyllium concentration of 35 g/l provides better results and can be used as a substitution to the conventional thickeners like sodium alginate and CMC.

4. Printing with other reactive dyes

For the confirmation of the above results and effect on the reactive dye class, samples were printed with 2 other commercial classes of reactive dyes i.e. Levafix Red CA-N (based on Vinyl sulphone and difluoropyrimidine) and Procion Red PX-8B (based on dichlorotriazine). Table 4 shows results of K/S, bending length, crock fastness and washing fastness of the samples printed with reactive dyes at the optimized concentration i.e. 35g/l of psyllium and conventional concentration of sodium alginate and CMC.

Table 4: Effect of type of reactive dye and thickener on the K/S, bending length and fastness properties

Dyes	Thickener	Concentration	K/S	Bending length (cm)	Rubbing fastness		Washing fastness	
					Dry	Wet	C/C	C/S
Levafix Red CA-N	Psyllium	35g/l	21.58	2.2	5	4/5	2/3	4/5
	Sodium Alginate	80g/l	18.52	3.6	4/5	4	3	4/5
	CMC	80g/l	18.24	3.4	4/5	4	3	4/5
Procion Red PX-8B	Psyllium	35g/l	28.98	2.3	5	4/5	2	4/5
	Sodium Alginate	80g/l	24.42	3.7	5	4/5	2/3	4/5
	CMC	80g/l	23.61	3.5	5	4/5	2	4/5

It was observed that the colour yield and bending length of the sample printed with psyllium was found higher than the sample printed with sodium alginate and CMC for both dye classes. The fastness properties in terms of crock and washing fastness were found comparable for all 3 thickeners w.r.t both dyes leads to conclude that psyllium as a thickener can be used on the all reactive dye classes without any problem.

5. Conclusion

This study showed that psyllium husk can work really well as a natural thickener for printing on cotton fabrics. When used at 35 g/L, it gave the best results which is smooth printing, bright colors, and a soft feel to the fabric. It performed as well as, or even better than, the commonly used thickeners like sodium alginate and CMC. The printed fabrics also had good washing and rubbing fastness, meaning the colors

stayed strong. Since psyllium is natural, cheap, and eco-friendly, it's a great alternative that can make textile printing more sustainable and less harmful to the environment.

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