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# Psyllium as an alternative natural thickener for the printing of wool

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**Abstract:**
An attempt has been made to study the effect of psyllium as a natural thicker for printing of wool using acid dyes. The optimization of process parameters such as concentration of psyllium and the viscosity of printing paste. The scoured wool fabric was printed with optimized recipe of psyllium and conventional thickener such as sodium alginate and gaur gum. The effect of different thickener on the fabric properties were studied in terms of colour strength, bending length i.e. stiffness of the fabric, fastness to rubbing, washing and water. The optimized psyllium concentration required for printing i.e. 3.5%, gives better yield, soft handle with comparative fastness properties at lower cost. As per available literature, Psyllium is the first time reported as thickener for printing of textile material.

**Keywords:** Psyllium, viscosity, acid dye, soft handle, color yield.

## 1. Introduction

Natural thickener has been used for printing of natural textile substrate such as wool, cotton, silk since the development of civilization (Hossain et al., 2016). With the advent of synthetic thickener in the early 20$^{th}$ century, uses of natural thickener declined to significant extend (Bajaj-Goyal and Chavan, 1993). With increasing awareness about ill effect effects of synthetic dyes and pigments for dyeing and printing, the demand for organic products, natural dyed and printed textile material increasing day by day (Ahmed et el., 2016; Ali and El-Mohamedy, 2011; Shabbir et al., 2016; Yusuf et al., 2016; Yusuf et al.,2015). In recent years, the use of synthetic thickeners and modified thickener is under severe criticism for their high water pollution at the manufacturing stage and washing of printing fabric. Synthetic thickener has many advantages over natural such as softer fabric handle, pseudoplastic rheology, high viscosity, consistency in viscosity, high reproducibility, smoother and sharper prints and better colour yield except of few limitations such as the environment risks due to their non-biodegradable nature, costly and sensitivity to electrolyte (Jassal and Bajaj, 2001; Hossain et al., 2016; Ahmed et al., 2016; Kokol, and Heine, 2005.). Alternatively natural thickener proved less hazardous due to their biodegradable nature. The basic requirement for selecting a thickener for print paste includes the compatibility with other print paste additives, good colour yield, ease of preparation, high viscosity at low add on, easily available at low lost, easily removal and provide softer handle to fabric(Clarke and Miles, 1981). The printing quality primarily depends on the physicochemical properties of the printing paste, as well as on the printing process conditions, the fixation process and the washing off of printing paste after fixation (Hossain et al., 2016;). Hardly, any single thickener able to meet these requirements under all practical situations. Among the wide range of natural thickener available in market such sodium alginate, guar gum, cellulose, starch etc. for printing of textile fabric materials, sodium alginate and guar gum are mostly commonly used thickener in textile printing.

Sodium alginate (natural polysaccharide) is a derived from seaweed, widely used thickener for reactive dye printing. The hydroxyl groups of most other carbohydrate materials are capable of reacting with the dye giving low color yields or unsatisfactory fabric handle, due to insolubilization of the thickener. Sodium alginate contains hydroxyl groups, but the reaction between alginate and dye is limited by mutual anion repulsion of the alginate's carboxyl groups and the dye's sulphonic acid groups. The repulsion additionally promotes migration of dye from the thickener into the fabric during steaming (Miles, 2003; Wang-Zhu and Danian, 2013;Fijan, Sostar-Turk and Lapasin, 2007). The wool fabric impregnated with sodium alginate paste and later printed with acid dyes using ink jet printer gives good results at a concentration of 6%. It was also studied that concentration of sodium alginate as a thickener has a little effect on color yield (Yuen et al., 2010). Guar gum (natural polysaccharide) is another popular thickener, a class of locust bean gum composed of sugar galactose and mannose. It is known for excellent print sharpness. Unmodified guar gum has a large number of hydroxyl groups forming a very complex cross-linking with the reactive dye, which leads to poor colour yield on the fabric (Shore, 2002; Fijan, Sostar-Turk and Lapasin, 2007; Teli-Sheikh and Shastrakar, 2014).

Psyllium, the seed of Plantago, is widely distributed throughout the temperate region of the world and has high economic value. The Psyllium seed yields colloidal mucilage consisting mainly of xylose, arabinose, galacturonic, 4-O-methylglucuronic acid, tannins, fatty oils (Duke, 1992). Psyllium has been widely recognized for its safe and cholesterol-lowering effects, effective laxative activity, and insulin sensitivity improvement capacity (Pal et al.,2012; Anderson et al.,2000) . Hence, it has no negative impact on the environment. Recently, its use as a flocculant for treating textile effluent has been reported (Mishra-Srinivasan and Dubey, 2002; Mishra et al.,). The rheology study of the psyllium at different concentrations, temperature and pH has been studied indicating its elastic properties and being an anionic polysaccharide, bears a negative charge due to ionized carboxyl groups (Farahnaky,2010). The psyllium crop may be good alternative commercial crop in winter season if commercially exploited as thickener for printing in Indian subcontinent.

In the present study, we reported the use of psyllium as a natural thickener for the printing of wool with acid dyes. The optimization of psyllium concentration for printing paste was carried.

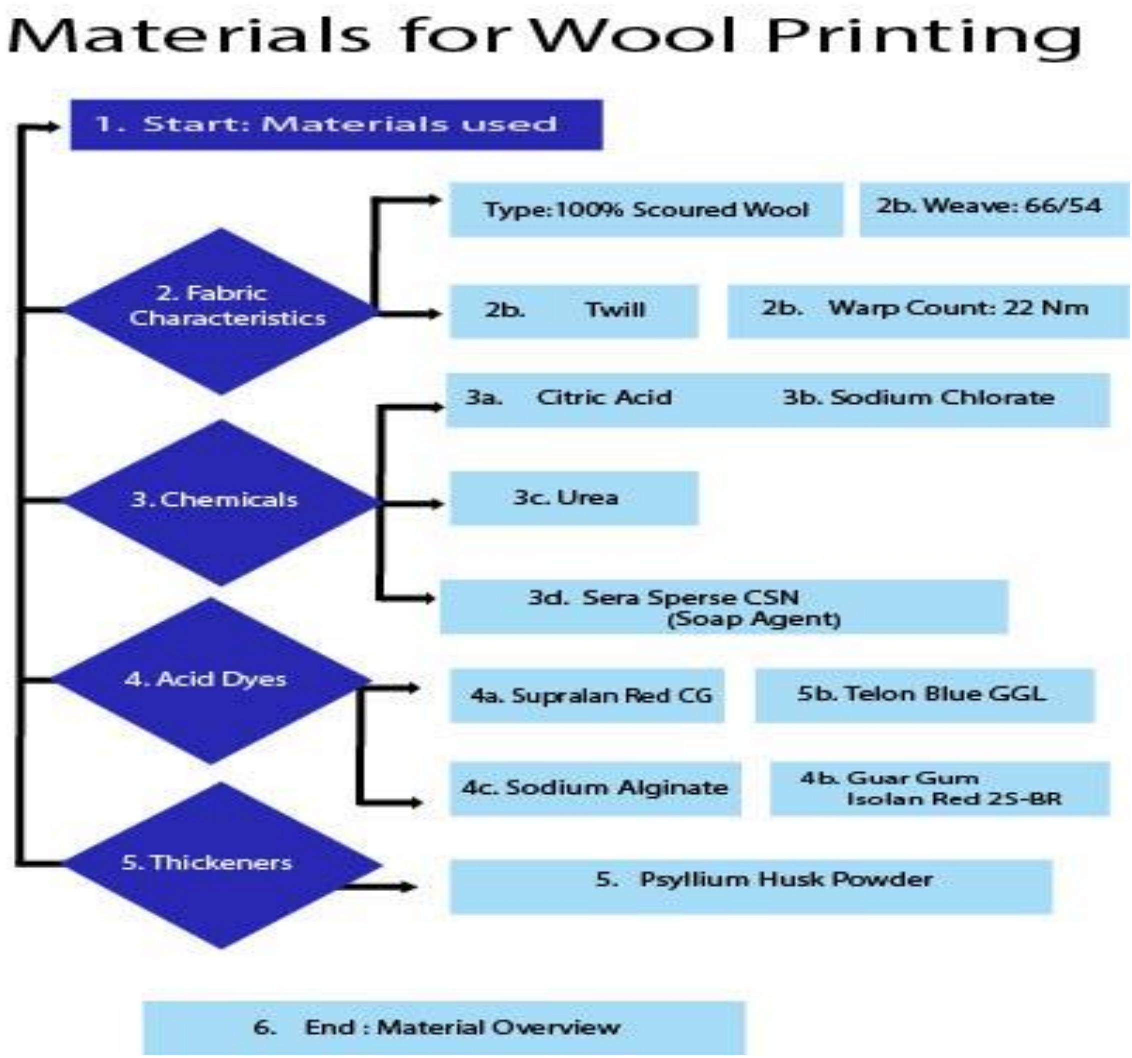
## 2.Methodology

### 2.1 Material

100% scoured wool fabric, having following fabric characteristic; twill weaved, EPI/PPI i.e. 66/54, warp and weft count i.e 22/42 Nm.

The chemicals used were citric acid, urea, sodium chlorate (provided by Merck Specialties Pvt. Ltd.) and Sera Sperse CSN (as a soaping agent) as commercial grade auxiliary supplied by Dystar India. Supralan Red CG (acid milling), Telon Blue GGL (acid levelling) and Isolan Red 2S-BR (1:2 metal complex) as acid dyes used for printing of wool were supplied by Dystar India.

Sodium alginate and guar gum as powder form were of laboratory grade whereas psyllium husk powder of commercial food grade supplied by Sidhpur (isabgol processing company), India.




## 2.2 Experimentation

### 2.2.1 Preparation of printing paste

The print paste was prepared by dissolving thickener powder in hot water with continuous stirring using mechanical agitator. The prepared paste was stored for overnight. Another paste was prepared by mixing urea in warm water and cooled to room temperature. To this, required amount of dye and other auxiliaries were added and stirred until a smooth paste was not obtained. Calculated amount of prepared thickener stock paste was added to this dye paste.

Table 1: Printing paste composition for Acid dyes

| Constituent | Concentration |
|---|---|
| • Psyllium/ sodium alginate / Guar Gum | $X^{\#}$/ 5*/ 5* (%) |
| • Dye | 2% |
| • Urea | 5% |
| • Citric Acid | 3% |
| • Sodium Chlorate | 1.5% |
| • Water | To make the paste volume 100 gm |

# optimized concentration
*minimum concentration used in conventional process

### 2.2.2 Printing of fabric

Print paste was applied to the wool fabric sample using flat screen printing technique. Printed wool fabric sample dried at 90°C for 5 minutes and steamed at 102°C for 15 minutes for dye fixation. The printed fabric washed with 2 g/l Sera Sperse CSN (soaping agent) at 60°C for 15 minutes to remove unfixed dye and print paste. After washing one warm and cold rinse was given to printed fabric. The fabric was dried at 90°C for 5 minutes.

### 2.2.3 Viscosity of the print paste

The viscosity of the print paste were measured at shear rate of 12 $(s)^{-1}$ and 25°C using Brookfield Viscometer, Model RVF. The apparent viscosity (η) was calculated using the following formula: $\eta = \tau/D$ Pa s, where D and τ are the rate of shear $(s)^{-1}$ and shear stress (dyne/cm), respectively.

### 2.2.4 Color Strength Measurement

Data color SF 600 reflectance spectrophotometer integrated with computer was used for measurement of colour characteristics in terms of relative colour strengths (K/S values). The colour strength in the visible region of the spectrum was determined on the basis of Kubelka-Munk equation (Yusuf-Mohammad and Shabbir, 2017).

$$\frac{K}{S} = \frac{(1-R)2}{2R}$$

Where K is the absorption coefficient, R is the reflectance of the dyed sample and S is the scattering coefficient.

### 2.2.5 Fastness Testing

The printed and washed wool fabric were subjected to following fastness tests, fastness to rubbing; AATCC 116. Colour fastness to washing: AATCC 61. Colour fastness to water: AATCC 107.

### 2.2.6 Fabric handle

The fabric handle can be determined by measuring bending length of printed wool fabric using fabric stiffness tester; ASTM (E290-09).

## 3. Results and Discussion

In this study, an attempt has been carried out to evaluate psyllium as an alternative to sodium alginate and gaur gum as a printing thicker.

### 3.1 Viscosity of the print paste

Figure 1 shows the effect of varying concentration of psyllium (0.5 to 5%) on the print paste viscosity. The viscosity of print paste increased at very slow rate upto 1.5% concentration of psyllium beyond that it increased at faster rate up to 4 % and then starts levelling off. From the results, it was observed that viscosity at concentration below 2% was very low and might not provide the appropriate viscosity to the printing paste for sharp prints

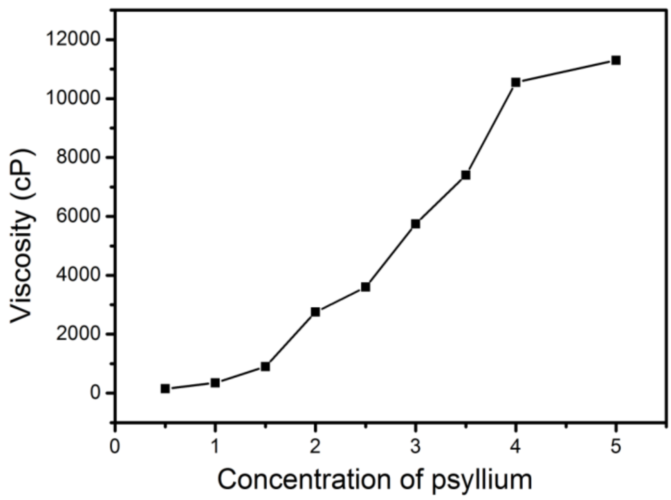



Figure 1 Viscosity of print paste at different concentrations of psyllium

### 3.2 Effect of psyllium concentration on colour yield

For the optimization of the psyllium's concentration for print paste, the effect of variation of psyllium concentration on color yield was studied. Supralan Red CG (Acid Milling dye) was used as an acid dye. Figure 2 shows an effect of the colour yield in the terms of K/S at $\lambda_{max}$ for samples printed with varying concentration of psyllium from 2% to 5%.

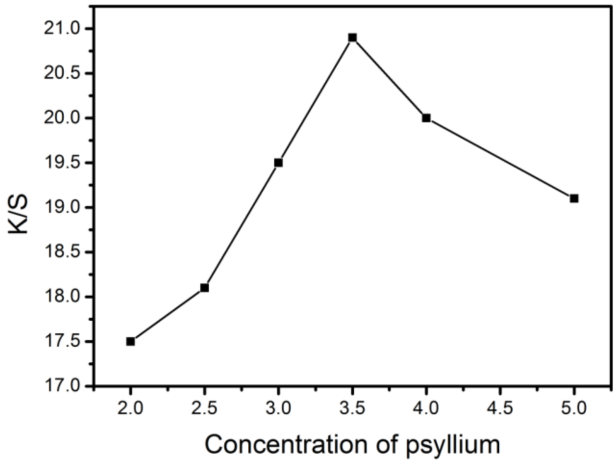



Figure 2. K/S values of printed samples at different concentration of psyllium

The result indicates that with the increase in the psyllium concentration, K/S increased up to the concentration of 3.5% beyond that K/S values decreases with further increase in thickener concentration i.e. (K/S values of 17.51 at 2%, 18.14 at 2.5%, 19.52 at 3% and 20.96 at 3.5%. 20.12 at 4% and 19.15 at 5%.). This may be attributed to the higher paste viscosity leads to poor transfer of the colour yield on the fabric. The K/S values of samples printed with sodium alginate was found lower than the K/S values of samples printed with psyllium at all concentrations. The sample printed with guar gum, gives comparative colour yield to samples printed with psyllium at different concentrations but psyllium's concentration was less as compared to the concentration used for guar gum. The optimum psyllium concentration for printing is 3.5%.

### 3.3 Bending Length

Figure 3 shows the results for bending length of the samples printed with varying concentration of psyllium from 2% to 5%.

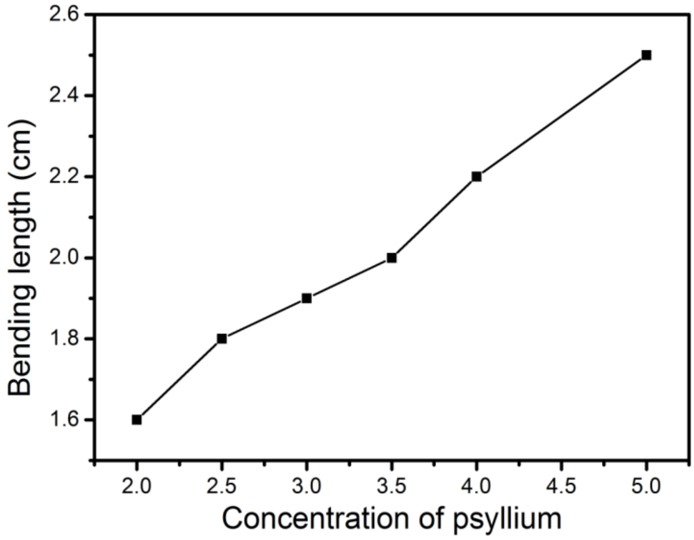



Figure 3. Bending length at different concentration of psyllium

The bending length of the samples increased with the increase in the concentration of thickener having a least value of 1.6 cm at 2% and highest value of 2.5 cm at 5%. 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. Bending length of the samples printed with conventional thickener like sodium alginate and guar gum was found to be 2.6 cm and 2.4 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 for wool fabric printing.

### 3.4 Fastness Properties

The rubbing, washing and water fastness of the samples printed with psyllium concentration at 3.5% and others with conventional thickeners were shown in table 2. The fastness properties in terms of rubbing, washing and water were found to be comparable for the samples printed with all thickeners.

Table 2: Fastness properties of the printed samples

| | | Rubbing fastness | | Washing Fastness | | Water Fastness | |
|---|---|---|---|---|---|---|---|
| Thickener | Concentration | Dry | Wet | C/C | C/S | C/C | C/S |
| Psyllium | 3.5% | 4 | 2/3 | 2/3 | 4 | 3 | 4 |
| Sodium Alginate | 5% | 4 | 2/3 | 3 | 4 | 3 | 4 |
| Guar Gum | 5% | 4 | 2/3 | 3 | 4 | 3 | 4 |

### 3.5 Printing with other acid dyes

For the confirmation of the above results and effect on the acid dye class, samples were printed with 2 other commercial classes of acid dyes i.e. Telon Blue GGL (acid levelling) and Isolan Red 2S-BR (1:2 metal complex). Table 3 shows results of K/S, bending length, rubbing, washing and water fastness of the samples printed with reactive dyes at the optimized concentration i.e. 3.5% of psyllium and conventional concentration of sodium alginate and guar gum.

Table 3: Effect of other classes of acid dyes on the K/S, bending length and fastness properties

| | | | | Rubbing fastness | | Washing fastness | | Water Fastness | |
|---|---|---|---|---|---|---|---|---|---|
| Dyes | Thickener | K/S | Bending length (cm) | Dry | Wet | C/C | C/S | C/C | C/S |
| **Telon Blue GGL** | Psyllium | 18.54 | 1.9 | 4 | 2/3 | 2/3 | 4 | 3 | 4 |
| | Sodium Alginate | 9.35 | 2.6 | 4 | 2/3 | 3 | 4 | 3 | 4 |
| | Guar Gum | 18.23 | 2.3 | 4 | 2/3 | 3 | 4 | 3 | 4 |
| **Isolan Red 2S-BR** | Psyllium | 20.23 | 1.9 | 4 | 2/3 | 2 | 3/4 | 3 | 4 |
| | Sodium Alginate | 11.37 | 2.7 | 3/4 | 2/3 | 2/3 | 3/4 | 3 | 4 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Guar Gum | 20.51 | 2.4 | 4 | 2/3 | 2 | 3/4 | 3 | 4 |

It was observed that the colour yield and bending length of the sample printed with psyllium was found comparable to sample printed with guar gum but gives higher K/S and softer hand-feel than samples printed with sodium alginate. The fastness properties in terms of rubbing, washing and water 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 acid dye classes without any problem.

**Conclusion**

The optimum concentration used for psyllium as a thickener for the flat bed screen printing is 3.5% and provide good results in terms of colour strength, softer handle as compared to sample printed with 5% of either sodium alginate or guar gum. Fastness properties in terms of rubbing, washing and water were found comparable for the sample printed with all the three thickeners. Psyllium as a thickener can be used for the all dye classes of acid dyes as it doesn't interact and can easily substitute the guar gum.

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