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Research Paper

Screen printing with tamarind seed gum on cotton fabric

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■ **ABSTRACT :** The most commonly used thickeners for printing cotton fabric is synthetic, but in view of eco friendly nature, partly substituting tamarind kernel powder represents an acceptable alternative. Therefore, an attempt was made to screen print cotton fabric with tamarind kernel powder with different concentration, evaluate the visual appearance of printed fabric for various parameters. Results revealed that 10 per cent concentration of thickening agent showed best results in terms of colour fastness to washing, perspiration and light and also possessed good physical characteristics. So this concentration of thickening agent was finally selected for the screen printing.

■ **KEY WORDS:** Tamarind kernel powder, Screen printing, Colour fastness properties

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Printing plays a major role in reviving traditional art form as it provides opportunities for innovative and new changes in apparels with respect to colour, design and style. Each printing method requires a paste or thickening agent with special characteristics frequently referred to as the flow characteristics. The types of thickening agent are quite diverse. Plant products are attractive alternatives to synthetic products because of biocompatibility, low toxicity, environmental "friendliness" and low price compared to synthetic products. Gum and starches from natural products is also generally non-polluting renewable sources for the sustainable supply. Natural gums and starches obtained from plants have diverse applications in textile wet processing. The utilization of any gum mainly depends upon its viscosity which varies a lot on particular source having Peculiar physico-chemical properties and fine structure of the starch / gum.

Increase demand, high price, scarceness of natural thickeners stimulate the search of locally available materials *i.e.*, suitable to be used as an alternative to the traditional thickeners. Various starch based thickening agent such as modified starch, CMC, PVA, Sodium alginates are commonly used. Alginates of different salts can be universally used in all different dye stuff but they are more expensive and the dye stuff yield is too low. CMC is also used rarely in textile printing as it is very expensive. Increase demand, high price, scarceness of natural thickeners stimulates the search of locally available materials *i.e.*, suitable to be used as an alternative to the traditional thickeners.

The synthetic thickening agents used are generally extremely high-molecular weight polymers capable of developing a very high viscosity at a relatively low concentration. However, the paste or thickening agents are difficult to dispose off as it creates sedimentation in the water during its waste disposal.

An increasing awareness about the realization that the intermediates and chemical used in synthetic dyes being toxic and hazardous to human health as well as to the environment, has led to the revival of interest in the non toxic ecofriendly colouring materials. A number of studies have been already conducted on extracting colour from natural dye sources like flowers, barks, fruits etc. which can be effectively used for dyeing of textile substrate. Seed gums are important agrochemical used in various industries worldwide. The growing industrial utility of these gums in the field of paper, textile, petroleum recovery and pharmaceutical industries has resulted in intensified research on new sources of gums and their modified products. In the present study, the researcher has tried to optimize the concentration of the tamarind seed gum or tamarind kernel powder (TKP) for the Screen printing process.

Tamarind seed gum or tamarind kernel powder (TKP) is derived from the seed of *Tamarind indica*. It belongs to the dicotyledonous subfamily *Caesalpinioideae* (Legiminosae). Tamarind seed gum, a crude extract of tamarind seeds, is rich in polysaccharide, which contain glucose, xylose and galactose units, in a molecular ratio of 3:2:1. It is insoluble in organic solvents and dispersible in hot water to form a highly viscous gel such as mucilaginous solutions with a broad pH tolerance and adhesively (Baveja *et al.*, 1998).

Moreover it has the potential for commercial applications in the textile printing as a thickening agent. Thus, as an alternative to synthetic thickening agent, natural biodegradable materials developed from tamarind kernel powder can be used during printing process. With the advantages of it being environmental friendly and also having a lower cost of production keeping this in mind the researcher has postulated the use of TKP as a natural thickening agent and in the present study has tried to optimise its concentration of use. Along with this an effort has also been made to diversify the rich cultural heritage. The major objective of this study is Screen printing with tamarind kernel gum on cotton fabric and judging its colourfastness properties.

■ RESEARCH METHODS

Selection and preparation of thickening agent:

On the basis of the survey tamarind seed was selected for the printing paste owing to their easy availability and low cost low cost of production. The tamarind seed pods were purchased from local market of Udaipur. The collected tamarind seeds were dried in a hot oven at 70°- 80°C for 30 mins and the seed coat was manually removed from the seeds. Then, milling was done followed by sieving in order to obtain the final tamarind kernel power.

Fabric:

Plain white cotton fabric was purchased from market. Scouring was done in order to remove the impurities from the fabric. Fabric was boiled for 45 min. in a solution containing 2 g of nonionic detergent and one gram of sodium hydroxide per litre of water. After this by kneading and squeezing the samples were rinsed in tap water and sun dried. To remove fats, oils and other impurities, the fabric was degummed by boiling using soap solution as reported by Clark (2011).

Table A : Specification of the fabrics used for Screen printing

Physical properties	Cambric (100% Cotton)
Texture	Soft and Smooth
Yarn count	84×73
Weight	125g/m^2
Thickness	27mm

Optimization of thickening agent concentration:

Various concentrations of thickening agent *i.e.* 8, 10, 12, 14, 16 g per 100 ml of distilled water were mixed followed by heating in the oven for 1 min for proper mixing of the tamarind kernel powder in the water. This was allowed to stand for few hours to attain full swelling of gum particle and was finally filtered.

Preparation of the printing paste:

After preparation of the thickening paste of different concentration, the fabric was printed with the following recipe given by Kale (1997):

30 parts procion colour
30 parts urea
230 parts water
650 parts thickening agent
60 parts sodium bicarbonate

Printing technique:

All the printing paste were applied to the fabric through screen printing technique. The printing process consist of forcing a various print paste through the open areas of the screen with a flexible, synthetic rubber, squeegee. The rubber blade, which is contained in a wooden or metal support, is drawn steadily across the screen at a constant angle and pressure. The pressures exerted must be as similar as possible.

Assessment of the printed sample (Visual evaluation):

The Screen printed samples with different concentration of thickening agent were visually evaluated by panel of experts from Textiles and Apparel designing department. The printed samples were displayed before the judges. The evaluation was done on the basis of the 5 point rating scale. The attributes for evaluation were uniformity of colour, sharpness of line and whiteness of ground. Total scores for each attribute was calculated and best 5 samples were selected.

The selected concentration samples were again tested for different physical characteristics (thickness, tensile strength, crease recovery, stiffness) and colour fastness properties (washing, perspiration, fading) in order to select the best sample for the final printing.

Testing of the physical properties of the selected samples:

Fabric thickness:

Thickness of the samples were measured as the distance between the reference plate on which the specimen rests and the parallel circular pressure foot under nominal pressure on the area under test. The method described in ISI (IS: 7702-1975) was used to measure the thickness of the samples. 'Fabric thickness gauze' was used for the test. The pressure foot and reference plate were cleaned and thickness gauze was set to zero. All the creases and folds were removed from the sample. The fabric was kept between the two parallel plates of thickness gauze and a known arbitrary pressure was applied between the plates and maintained for 30 seconds. The distance between the plates was measured at 3 different places and the mean value was calculated.

Tensile strength test:

Tensile strength of the unprinted and printed fabric with different concentration of selected thickening agents was measured by tensile strength testing machine. Ravelled strip test method as described in ISI (IS:1969-1968) was used to measure the breaking strength of the samples. The warp way and weft way test specimen of 6x4 cm were cut from the fabric. The lengthwise side was kept parallel to the warp and weft direction for which the breaking load was required. The yarn at the edges were ravelled away to obtain specified width *i.e* 30x5 cm. The test specimen was mounted centrally in the clamp with the longer side parallel to the direction of application of load. Continuous load was applied longitudinally to the specimen ruptured with the speed of 75mm/minute. Values of breaking load of the test specimen were read directly on the digital screen. Total three observations were recorded for each sample and mean breaking load was calculated separately for warp way and weft way test specimen.

Crease recovery:

Determination of wrinkle recovery or crease resistance of the fabric, which enables the fabric to resist wrinkling or mussing, was done by measuring the 'crease recovery angle'. Crease recovery angle was measured as per ISI (IS: 4681-1968) on 'crease recovery tester'. A rectangular specimen of two inch long and 1 inch wide was cut folded precisely in half and placed on the anvil under 2kg weight of loading device for 1 minute for creating the crease in the fabric. After the load was removed and specimen was directly transferred to the instrument by holding 1 limb in the clamp of the instrument. The specimen was allowed to recover from the crease. The dial of the instrument was rotated to keep the free edge of the instrument in line with the knife edge. After 1 minute, the period allowed for recovery, the recovery angle in degrees was read on the engraved scale. Three observations were taken and mean value for the recovery angles were calculated for the warp and weft direction of each test fabric.

Fabric stiffness test:

To determine the stiffness of the fabric *i.e*. resistance of fabric to bending, cantilever test as described in ISI (IS: 6490-1971) was used. The instrument used was 'cloth stiffness tester'. A rectangular specimen was cut from the fabric to be tested according to the size of bending length scale *i.e.* 6 x 1 inch. The specimen was placed length wise on the platform with one end coinciding with the upper front edge of the platform. The bending scale was placed over the test specimen in such a way that the zero of the scale coincide with the datum mark on the body of instrument. The specimen and scale were pushed forward gently and slowly until the leading edge of the specimen projects beyond edge of the platform and overhangs like a cantilever and bends downwards. The length of the overhanging portion of the sample was read from the scale, when the edge of the sample coincides with the inclined lines of the tester. Same test were repeated for three samples both in warp and weft direction and bending length was calculated by following formula given by Booth (1947).

Bending length = L/2 cm

where,

L= The mean length of overhanging portion in cm

Testing of the colour fastness properties of the selected samples:

Colour fastness to washing :

This test was carried out according to ISI recommended test number 3. For testing, printed samples were kept in between of two unprinted cotton fabrics measuring 5x 5cm.The three pieces were held together by sewing all four sides to form a composite specimen. The washing solution was prepared by dissolving 5ml of liquid soap (non ionic detergent) and 2g of sodium carbonate (Na_2CO_3) in 1000ml of water maintaining the material liquor in a ratio 1:50. The test was carried in the standard apparatus launderometer containing a rotor with which containers made up of stainless steel of 500ml capacity with a tight fitting lid .These jars were rotated for 45 minutes at the constant temperature of about 60 ± 2^0C. The temperature was maintained by thermostat controlled water bath. The composite specimen was removed from the jar after 30 minutes, rinsed under running water and dried in shade. The stitches of specimens were removed along two long sides and one short side. The samples were analyzed accordingly for washing fastness and staining using the following grey scale. The grey scale rating

For the washing fastness		For staining on adjacent fabrics	
Rating	Remark	Rating	Remark
1.	Poor	1.	High staining
2.	Fair	2.	Staining
3.	Good	3.	Slight staining
4.	Very good	4.	Negligible staining
5.	Excellent	5.	No staining

Colour fastness to perspiration:

Perspirometer was used to determine the fastness of coloured textile to the effect of perception. For testing, 5x5 cm size of specimen was cut and sandwiched between two unprinted samples of the same dimension, and stitched along the edges. The composite specimen was immersed for about 30 minutes in the freshly prepared artificial perspiration solution with occasional agitation and squeezing to ensure complete wetting. Alkali perspiration solution was prepared by dissolving 3 g sodium chloride per litre of water, adjusting the pH 7.2 with the addition of sodium carbonate. Acid perspiration solution was prepared by dissolving 2.65 g sodium chloride and 0.75 g urea per litre in water, adjusting the pH 5.6 with the addition of acidic acid. The wetted sample were taken out after 30 minutes from the perspiration solution and placed inside the Perspirometer weight of 4.536 kg was kept over the meter and screwed. The set was left for 4 hours. Then the dried samples were finally assessed for staining against gray scale (1-5) rating.

Colour fastness to fading to light:

For testing, five selected printing sample of 10x2 cm size were kept inside the MBTF lamp where one side light is exposed to printed samples and another side is controlled without exposing towards light. The test was carried out in the standard apparatus *i.e.* Fedometer which consists of centrally located MBTF lamp fitted vertically at the centre of an aluminium cylinder coated with tungsten filament which emits yellow and red light. The printed sample was kept inside the sample holder, designed at ATIRA for assessing the fading quality of specimens. The cylinders have a shelf around the inside for holding a small mass of solid/liquid to control the humidity. The temperature was maintained at 50°C by thermostat control and the specimen were exposed for 12 hours in the Fedometer. The test specimens were drawn and analysed on 8 point rating scale ranging from excellent to very poor.

■ RESEARCH FINDINGS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Optimization of the concentration of thickening

agent through visual evaluation :

Screen printed sample using different concentration of thickening agent (8g, 10g, 12g, 14g, 16g,) were visually evaluated by a panel of experts for various attributes *viz*., sharpness of outline, whiteness of ground, uniformity of colour and overall appearance. Table shows that on the basis of uniformity of colour Screen printed samples with 10 per cent was given the highest preference with a total marks of 23 out of 25 followed by 10 per cent concentration with a total marks of 22 out of 25.The next preferred concentrations on the basis of uniformity of colour were 2.5 and 2 per cent with a total marks of 21 followed by 8 per cent concentration with 20 marks. It is clearly visible from the table that the printed sample were not uniform in the lower and higher concentration hence least preferred by the judges.

In terms of sharpness of line, 12 per cent concentration was highly preferred by the judges with a total score of 23 out of 25 followed by 10 per cent concentration with 22 marks whereas samples with 8 and 12 per cent concentration were next preferred with 20 marks. Thickening agent with higher concentration 16 showed poor results in terms of sharpness of line. In terms of whiteness of ground again the top two concentrations were 10 and 12 per cent with a total score of 24 and 22 marks, respectively, followed by 8 and 14 per cent of concentration with a total of 21 marks out of 25. The next preferred concentration was 16 per cent with 18 marks. In terms of overall appearance printed sample with10 per cent with total marks of 24 out of 25 was highly preferred followed by 2.5 per cent concentration with 22 marks. The next preferred printed samples in this direction were 2 and 3 per cent concentration with a total of 21 marks followed by 3 per cent concentration with a total of 18 marks out of 25.

Physical characteristic of the printed fabric :

Fabric thickness:

It is evident from the table that thickness of the fabric slightly increases when compare to the unprinted fabric. The unprinted cotton fabric have a thickness of 0.20mm whereas the fabric printed with 8,10, and 12 per cent thickening agent showed a slight increase in the thickness 0.22 mm thickness. While for 14 and 16 % the thickness was found to be 0.24 mm.

Tensile strength:

The tensile strength of the unprinted fabric was 14.2 and 15.0 kg in warp and weft directions. Whereas the tensile strength of the printed fabric ranged between 15.1-17.0 kg in warp direction and in weft direction it ranged between 14.6 – 15.9 kg. Maximum tensile strength was seen at 14 % while minimum was noted at 8.0% concentration. Thus it is clear from the table that tensile strength increases with the increase in the concentration of thickening agent.

Crease recovery:

Printed fabric showed decline in the crease recovery in both warp and weft direction as compare to

Table1: Visual evaluation of printed sample at different concentration of Thickening agent (n=5)

Sr. No.	Thickening agent %	Uniformity of colour	Sharpness of line	Whiteness of ground	Overall appearance	Total
1.	8 %	21	20	21	21	83
2.	10 %	23	22	24	24	93
3.	12 %	22	23	22	22	89
4.	14 %	21	19	19	19	78
5.	16 %	18	16	18	18	70

Table 2 : Effect of thickening agent on physical characteristics of the printed fabric

Fabric	Concentration of thickening agent (%)	Thickness (mm)	Tensile strength (kg)		Crease recovery (^{o})		Stiffness (cm)	
			Warp	Weft	Warp	Weft	Warp	Weft
Unprinted		0.20	14.2	15	77	80	1.8	1.5
Printed	8 %	0.22	15.1	14.6	79	83	2.3	1.7
	10 %	0.22	16.3	15.2	80	85	2.4	1.9
	12 %	0.22	16.7	15.6	83	87	2.5	2.0
	14 %	0.24	17.0	15.9	87	90	2.6	2.2
	16 %	0.24	16.9	15.7	86	89	2.5	2.2

the unprinted fabric. Unprinted cotton fabric had crease recovery of 77^o in warp direction and 80^o in weft direction whereas the printed fabric showed a crease recovery ranging between 79 – 88^o in warp direction. While in weft direction it showed a recovery ranging between 83 – 90^o. Minimum crease recovery was seen at 8.0 % level while maximum was noted at 14.0 % for both warp and weft direction. 10 per cent concentration of thickening agent showed a crease recovery of 80^o in warp direction and 85^o in weft direction.

Stiffness (Bending length):

Stiffness of the unprinted fabric was observed by measuring bending length and the results were presented in the Table 2. Bending length was measured in both warp and weft directions of fabric. Bending length for unprinted fabric in warp and weft directions was found to be 1.8 cm and 1.5 cm, respectively whereas the application of printing paste showed a slight increase in the bending length for both warp and weft direction which ranged between 2.3 – 2.6 cm in warp direction and 1.7 – 2.2 cm in weft direction. The bending length was observed to be 2.0, 2.6cm warp direction at 12 per cent concentration, respectively. For 12 and 16 per cent concentration the bending length was found to be 2.5 cm while 2.6 cm at 14 per cent in warp direction. The bending length in weft direction was found to be 1.7, 1.9 and 2.0 cm at 8, 10 and 12 per cent concentration, respectively. Whereas 2.2 cm bending length was observed for 14 and 16 per cent concentration of thickening agent.

Colour fastness to washing:

The ratings for washing fastness were given on the basis of change in colour as well as staining on adjacent test fabric. It can be noticed that washing fastness of all the samples was good to excellent 3/5 to 5. Printed sample with 10 per cent concentration showed excellent fastness (5) to washing followed by 2.5per cent thickening agent with 4/5 washing fastness whereas samples with other concentration shows good colour fastness (3/5).Both the test specimens of unprinted cotton fabric remained completely unstained and there was no colour change (negligible staining) in the printed sample with 10 per cent concentration of thickening agent followed by 12 and 14 per cent concentration which showed slight staining in test specimen, while maximum staining was observed in 8 and 16 per cent concentration. The superior washing property of colourant may be due to the kinetics and thermodynamic effects of the metal complex formation (Popoola, 2000).

Colour fastness to perspiration:

It is very important factor for the fabric used in apparels. This test was conducted on both against acid and alkaline artificial solutions of perspiration and it was observed that Screen printed cotton samples at different concentration showed best results for alkaline perspiration solution. It was observed that staining on the adjacent test specimen showed slight to negligible staining in alkaline solution in which 10 and 8 per cent solution showed excellent results and slightly stained for 14 and 16 per cent. Change in staining in different concentration of thickening agent in acidic medium was found to be better for 10 and 12 per cent concentration when compared to the rest of the selected concentration of thickening agent. It is evident from the table that no change in the colour value was in alkali medium for all the selected concentrations. No colour change in the acid medium was observed at 10 per cent concentration. Slight change was noted in the concentration of 2.5, 3 and 3.5 per cent while maximum change was observed at 2.0 per cent concentration.

Colour fastness to fading to light:

Light is the most important factor responsible for

Table 3 : Colour fastness properties of the different concentrations of thickening agent

Paste No.	Thickening agent %	Washing fastness		Perspiration fastness				Sunlight fastness
		Staining	Colour change	Staining		Colour change		
				Alkali	Acid	Alkali	Acid	
1.	8 %	3	3	5	3	5	3	7
2.	10 %	5	5	5	4	5	5	8
3.	12 %	4	4	5	4	5	4	8
4.	14 %	3	4	4	3	5	4	7
5.	16 %	3	3	4	3	5	4	7

fading of printed fabrics. Light fastness of printed fabric is influenced by chemical, physical state and concentration of dye, nature of the fibres and mordant type. Cristea and Vilarem (2006). The light fastness was measured by the fading of dyed or printed colours in light. It is suggested that fading may be due to some kind of breakdown in the light energy absorption capacity of the electrons of the chromospheres or a breakdown in the structure of the dye molecule. When sunlight energy is absorbed, the loosely held electrons of the chromospheres are raised to a higher energy level; that is, they become more active. It is known that ultraviolet component of sunlight will in time initiate chemical reaction. Such chemical reaction will be accelerated under moist conditions.

Fading in sunlight is due to partly to ultraviolet radiation that initiates chemical degradation of loosely held electrons of chromophores. Fading of dyed or printed textile material does not occur so readily in artificial light, mainly incandescent and fluorescent light, as these light sources don't emit significant quantities of ultraviolet radiation. In this study, fading was taken as a criterion for light fastness of the printed samples. Fading of the samples was evaluated by the exposed and unexposed portion of the samples in contrast to the blue wool standards. Light fastness of printed fabric is influenced by chemical, physical state and concentration of dye, nature of the fibres and mordant type. Cristea and Vilarem (2006). Light fastness of the Screen printed cotton fabric at different selected concentration of thickening agent was presented in Table 3. The Table 3 clearly shows that 8 and 10 per cent concentrations of thickening agent scored maximum score on the grey scale for light fastness followed by the rest of the concentrations. Hence, 10 per cent concentration of thickening agent was found to be the best to be used during the printing process and was thus selected.

Conclusion:

This research investigated on the application of a thickening agent based on tamarind kernel powder for screen printing on the cotton fabric. In present research work five different concentrations 8, to 16 per cent was used and it may be concluded that considering results of all the aspects visual evaluation like uniformity of , sharpness of line, whiteness of ground and overall appearance and physical testing 10 per cent concentration of thickening agent showed best results. The visual appearance of the entire cotton printed sample with 10 per cent concentration was very good. Crease recovery, bending length and fabric stiffness increased as the concentration of tamarind kernel powder increased. Looking to above results it can be concluded that tamarind kernel powder has vast avenues as a thickening agent in textile field**.**

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